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AUTOMATIC WEAVING

by

WILLIAM A. HANTON
M.Sc.(Tech.), Manchester
HEAD OF THE WEAVING SECTION OF THE
DEPARTMENT OF TEXTILE INDUSTRIES IN THE COLLEGE OF TECHNOLOGY, MANCHESTER, AND
LECTURER IN WEAVING AND TEXTILE ENGINEERING IN THE UNIVERSITY OF MANCHESTER
AUTHOR OF "MECHANICS OF TEXTILE MACHINERY"

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PREFACE

ALTHOUGH chapters on automatic looms have been included in more than one book on weaving mechanism, the subject has not been so fully treated as its importance demands. The increasing interest in automatic weaving, that has resulted from competition in cloth manufacture all over the world, has led to the preparation of this book, in the hope that it may be of some interest and use to the cloth manufacturer and the student of textiles.

It has not been possible to include descriptions of all the different types of automatic looms, but the majority of those that have proved successful or that are of exceptional interest have been included. Some of the looms have already been adequately described in other books, and whilst the reader's attention has been directed to these, sufficient mention has been made of such looms as was necessary to bring out their main characteristics.

The illustrations have been prepared with the one aim of making the action of the mechanisms as clear as possible. All detail not necessary for that purpose has been omitted. The drawings are not to scale, and parts have frequently been drawn out of proportion, or even out of their proper places, if their action has been rendered clearer by doing so.

The author has attempted to state, as fairly as possible, the case for the automatic loom against the ordinary loom, as well as the relative advantages of the different types of automatic looms. Consideration has also been given to the best yarn preparation for automatic weaving and to the lay-out and organisation of the weaving shed.

The author takes this opportunity of thanking the firms of machine makers who have helped by giving, so willingly, much useful information and the use of blocks and photographs, particularly Messrs The British Northrop Loom Co., Ltd., Messrs Vickers (Crayford), Ltd., Messrs George Hattersley & Sons, Ltd., and Messrs Urquhart Lindsay and Robertson Orchar for particulars of their new automatic loom for jute fabrics.

The author also thanks Mr J. M. Essam, M.Sc.(Tech.), for valuable help in reading the proofs.

W. A. HANTON.

MANCHESTER,
March 1929.

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CHAPTER I

INTRODUCTION

From the earliest days of power-loom weaving it has been realised that one of the chief defects of the loom lay in the necessity for stopping it every few minutes for the purpose of replenishing the weft in the shuttle, and inventors have never ceased in their endeavours to render the loom automatic by providing some form of continuous weft supply. This is desirable in modern weaving, not so much from the point of view of keeping the loom running continuously and so increasing the running efficiency, nor for the production of better cloth, but chiefly to enable the weaver to supervise a much greater number of looms and so reduce the cost of weaving, which, apart from the cost of the material, is mainly due to the wages of the weavers. But the addition of a satisfactory weft-replenishing motion to an ordinary power loom would not, by itself, enable the weaver to look after many more looms, for, on the average, a weaver does not spend more than about one-third of her time in changing the shuttle, the remainder being spent in attending to the loom when it has stopped for some cause other than the exhaustion of the weft supply, and in looking round the looms to see that no faults, particularly breaks in warp threads, have occurred in her absence. Since it is no uncommon experience for the introduction of automatic looms to enable the weaver to supervise from four to six times as many automatic as ordinary looms, it will be realised that the automatic loom is generally considerably more than an ordinary loom fitted with a weft-replenishing motion. The other most important addition to the mechanism of the loom is a warp stop motion, to free the weaver from the anxiety of being constantly on the look out for broken warp threads, which, apart from the replenishment of the weft, are generally responsible for more loom stoppages than any other cause. Again, in the automatic weaving shed assistance is generally provided to the weaver for carrying out many of the less difficult of her duties, such as carrying weft to the looms and removing the cloth. These points will be considered in greater detail later, but it will be realised that the capital cost of the machinery in an automatic weaving shed is high, as compared with the cost of ordinary looms, for, in general, the automatic loom produces little, if any, more cloth than the ordinary type, whilst the wages paid to weavers' assistants are considerable.

These, and other factors, such as the greater difficulty sometimes experienced in weaving certain fabrics as satisfactorily on automatic looms as on ordinary ones, account for the comparatively slow rate at which automatic looms have been adopted and for the fact that many manufacturers, particularly in Great Britain, are not yet convinced of their superiority over the ordinary loom, especially when highly skilled labour is available. But, although the claims made on behalf of the automatic loom are often extravagant, and although there are certain cloths which it is difficult, if not impossible, to weave satisfactorily on the automatic loom, there can be no reasonable doubt that for the majority of fabrics automatic weaving has decided advantages over weaving on ordinary looms, advantages that are becoming more marked as the difficulties of automatic weaving are becoming better understood, and as the number of loom types available to the manufacturer is increased.

Many attempts have been made in the past, and many more are likely to be made in the future, to change the intermittent actions of the power loom into a continuous action, to secure a continuous laying of the weft amongst the warp threads, and to get an increased production of cloth, since with the ordinary intermittent action the shuttle is inactive for three-quarters of the time the loom is running. None of these attempts has been commercially successful, and none has been adapted to an automatic weft supply. Nor has any marked success attended the efforts of those inventors who have used a weft supply outside of the shuttle, and have used the latter or some other device for inserting one or two picks of weft from this outside supply, a method which lends itself naturally to automatic weaving, since the weft package may be as large as is desired and can easily be replenished without stopping the loom. Although there are possibilities in both of these methods, the automatic looms which have been successful, up to the present, work on the same principles as the ordinary loom, the main actions of shedding, picking, and beating up the weft being carried out in the same way as in the ordinary loom. In these automatic looms, the weft supply is replenished either by a fresh cop or pirn being automatically forced into the shuttle to displace the exhausted cop, an action which generally takes place without any loss of speed by the loom, or else the whole shuttle, with the exhausted cop, is removed from the loom and a fresh shuttle, with a full cop, substituted, an action which is generally carried out after the loom has been automatically stopped, and which is then followed by the automatic re-starting of the loom. The relative advantages of these two methods are considered in Chapter II.

The first recorded attempt to provide a power loom with an automatic and continuous supply of weft was made in 1834 by John Reid and Thomas Johnson, who claimed to provide a "mechanism for changing shuttles when any one weft thread breaks or fails, the said mechanism then substituting spare shuttles by an instantaneous movement without any act of the attendant and without stopping the loom." This changing device was brought into action by a weft stopper fixed to the shuttle. A few years later, in 1840, Charles Parker invented a method by which a spent shuttle was automatically ejected and a loaded one inserted, and this was followed in 1852 by a patent granted to William Newton for a communication describing a different method of doing the same thing. In 1857 Patrick M'Farlane patented a device for placing a cop in a case and inserting and ejecting the cases when necessary, and this cop-changing device was followed by one in 1860, patented by Thomas Ingram. Many other shuttle-changing devices were tried, working on many different principles; sometimes the shuttle has been inserted at the top of the shuttle box, sometimes at the bottom; in other looms at the front or the back of the box. Drop boxes or revolving boxes have been used to move away the exhausted shuttle and bring the new one into action. Some of these are still used, but the most successful type removes the empty shuttle from the front of the shuttle box, and immediately thereafter inserts a full shuttle to take its place. Sometimes the shuttle change has been carried out at the full speed of the loom; in other methods the loom speed has been reduced during the changing period, whilst in the most successful type the loom is stopped for the change.

Although attempts had been going on in this way since 1840, it was not until J. H. Northrop invented his cop changer and patented it in the United States of America in 1894 that the automatic loom really became a serious competitor of the ordinary power loom. Northrop, although his loom was originally developed in America, was born in Yorkshire, which is also the native place of Samuel Jackson, who invented one of the most successful shuttle changers, his method being used in the Hattersley loom, and also by the Stafford Loom Company in the United States, where Jackson went to develop his invention. The Northrop cop-changing looms have revolutionised cotton weaving in America, and the principle of the Northrop system of changing the cop is used in most cop-changing looms and weft-replenishing attachments that are manufactured to-day. But although Northrop looms, in addition to being made in America and on the Continent of Europe, have been manufactured in Lancashire since the beginning of the present century, they have not yet been adopted, on any extensive scale, by Lancashire manufacturers. It was about the beginning of the present century also that Jackson's loom was introduced in America, and it is now extensively used in that country. This loom was not available for use in Great Britain until 1928, when the firm of Messrs Vickers (Crayford), Ltd., having obtained the right of manufacturing and marketing the loom throughout the world (except in America, Canada, and Mexico), started to manufacture the looms on an extensive scale. Although denied the use of the Stafford loom, Lancashire has had, in the past, the chance of trying an automatic shuttle changer embodying the main features of Jackson's invention, for, as will be seen from the description of the two looms, the Hattersley loom works on the same general lines as the Stafford, and has been available in Lancashire and Yorkshire for many years.

The desire to get the advantages of an automatic loom without scrapping existing looms and substituting the much more costly automatic machines has recently led many inventors to try to fit weft-replenishing and other attachments to existing power looms of the ordinary type. Some of these have been fairly successful, but their use is limited by the fact that it is of little use fitting them to other than new or nearly new looms, whilst the cost of fitting parts such as the warp stop motion, which are practically essential to any system of automatic weaving, when added to the cost of the weft replenisher, brings the total to a figure not far short of the price of a complete automatic loom. Recently also many attempts have been made to introduce looms and attachments for inserting the weft in single or double picks from a stationary weft supply package or packages. These systems have certain inherent advantages, such as a weft supply that is practically inexhaustible, whilst the warp shed required for the insertion of the weft need only be a shallow one, which reduces the stresses and the number of breakages in the warp threads. But they have equally well-defined disadvantages, such as the fact that the weft must either be introduced in double picks or cut at one or both selvedges, whilst the mechanism used is not generally so simple and satisfactory as that used in fly-shuttle looms. For certain fabrics these methods of inserting the weft are satisfactory and, indeed, advantageous, but they are not well suited to the production of all kinds of woven goods, and hence are not likely to displace the older system unless they show marked superiority in production or in quality of cloth.

CHAPTER II

CHARACTERISTIC AND ESSENTIAL FEATURES OF AUTOMATIC WEAVING

For successful automatic weaving it is essential that the causes of loom stoppages should be reduced to a minimum. The most obvious cause is the replenishment of the weft, but although a satisfactory weft replenisher may be considered to be the central feature of the automatic loom, it is by no means the only thing needed to keep the loom running without attention. The other most important things are a warp stop motion and an automatic let-off motion, whilst it is desirable that the warp and weft should be so prepared for the loom that the number of loom stoppages due to failure of either warp or weft is not excessive. The waste of weft should also be small, a matter which depends partly on the preparation and partly on an efficient feeler in the weft-replenishing mechanism. There are arguments in favour of most of these, such as good preparation, for the ordinary loom as well as the automatic, but without doubt the average standard of preparation as used for ordinary looms is not good enough for successful automatic weaving.

Weft replenishment is carried out either by changing the cop or pirn, by changing the shuttle, or by special mechanism for inserting single or double picks from a large weft supply, which is not carried to and fro in a shuttle, but remains always in a fixed position.

Judged by the number of looms in use, the cop-changing systems, such as that used in the Northrop loom, are the most successful. The new cop or pirn is forced into the shuttle by means of a hammer, the entry of the new cop ejecting the spent one. A special self-threading shuttle must be used, and the whole operation is generally carried out at the full speed of the loom. In shuttle-changing systems the loom is generally stopped whilst a shuttle with a full pirn is brought into use and an empty one discarded, the stopping and restarting of the loom being done automatically.

Although cop-changing looms have been more popular than shuttle changers in the past, the latter have many points in their favour. Cop changing entails the use of special shuttles, which are expensive and generally heavier than those used for shuttle changing. The shuttles have to be strong to stand the transfer of the weft bobbins, and the wear resulting from this is probably more than that on the shuttles of the shuttle changer. Moreover, the heavy shuttle means wear and tear on the picking and shuttle-checking mechanism. Greater disadvantages than these are the suddenness of the transfer and the danger of cut weft ends being drawn into the cloth. The time available for the transfer is only about one-tenth of a second, and during that time the new pirn is forced into the shuttle with some considerable noise, which is disconcerting to the weavers. The sudden transfer and the method of threading is somewhat harsh on the weft thread, and there can be little doubt that a slightly better weft is needed than on the ordinary loom or the shuttle changer, whilst with very fine weft and some artificial silk the transfer and threading are liable to cause much trouble. Except when change is made by the weft fork when the weft runs out or breaks, the old bobbin when it is knocked out of the shuttle ought to take with it the end of the weft, drawing it clean through the shuttle eye. To enable it to do this, the weft must be cleanly cut between the shuttle and the cloth selvedge, as unless it is properly severed, and the cut end released, the bobbin will fall but will leave the old thread in the shuttle eye. When the shuttle is picked across, it threads up the new weft, but takes with it also the end of the old weft, which generally breaks where it has been partially cut. A double pick is thus inserted, which may extend nearly across the cloth. Again, a part of the old weft, usually 4 to 6 inches in length, is left between the selvedge and the thread cutter when transfer takes place, and it is equally important that the end of this piece should be held at the cutter until a cutter in the temple can cut it close to the selvedge. If the end is not securely held it may be drawn in with the shuttle, again resulting in a fault.

The shuttle-changing loom is much freer from these faults than the cop changer. When the shuttle is ejected it takes its old weft with it, and the piece of weft is held between the selvedge and the shuttle until the temple thread cutter severs it. The change of shuttles is done slowly, as a rule, the loom stopping for a few seconds to allow of the transfer. This, of course, loses a few picks, but that is a matter of small importance compared with getting a gentle transfer of the shuttles, which is done quietly and which throws practically no stress on the weft thread. It is impossible to transfer a bobbin gently with the loom running at full speed, or even if the loom is stationary, since considerable force has to be applied to effect the transfer, but with suitable mechanism it is possible to change the shuttles as gently as necessary. Shuttle-changing looms require a large stock of shuttles, but these are individually cheaper than the shuttles for cop-changing looms. It is also admittedly difficult to match these shuttles for size and weight, and this must be done if the looms are to work satisfactorily; it can be done if care is taken in sorting out and weighting the shuttles, if necessary, before issue from the stores. The shuttle changer does not always place the new shuttle in exactly the same place in the shuttle box, and hence the first pick after the change is liable to vary, and may cause the loom to bang off. This is made worse by the fact that the shuttle is not placed in actual contact with the picker, which reduces the effectiveness of the pick, and a stronger pick is needed from the magazine side than from the other. The shuttle changer is no harder on the weft than the ordinary loom, and it is as suitable as the latter for using the weft in mule cops, ring frame bobbins, pirns or solid cops, though for mule weft and small ring bobbins it will often pay to rewind the weft to larger pirns to get the full advantage of the automatic loom. The shuttle changer has a decided advantage over the cop changer for artificial silk weft, since the shuttle-changing loom can use an artificial silk shuttle similar to the type found most satisfactory on ordinary looms, whereas the cop changer must have a self-threading type. On the other hand, the cop changer is the only system that has been adapted to work on looms requiring more than one kind or colour of weft.

It will be realised that each type has its advantages and disadvantages, whilst both introduce some difficulties which are not met with in weaving on ordinary looms, difficulties that are in no small measure responsible for the slowness of certain branches of the weaving industry to adopt the automatic loom.

The cloth woven on looms without shuttles is generally more or less defective at the selvedge. Continuous weft can only be used in such looms with double picks in each warp shed, a loop of weft being carried through from the supply side and fixed by a catch cord at the opposite selvedge. If single picks are required in each shed, as is the case in the majority of fabrics, the weft must be cut, although this may be done only on alternate picks at each selvedge.

The warp stop motion nearly always consists in having a drop wire or detector suspended on each warp thread, the failure of the thread allowing the wire to drop into contact with and stop a moving part which, when so stopped, is instrumental in stopping the loom. These stop motions are liable to give a certain amount of trouble. The drop wires rub the yarn to some extent, which is particularly detrimental, on the one hand, to yarns of poor quality, and also to fine and delicate material on the other. It is difficult at times to prevent some of the warp threads from becoming slacker than the others, especially when the warp is on two beams, and a slack warp thread is liable to stop the loom, although the slackness may not be detrimental to the particular cloth being woven.

Automatic let-off motions, whose function it is to keep the warp tension constant as the beam weaves down, are found in considerable variety. Not a few automatic looms, especially looms converted from ordinary ones by the addition of a weft replenisher and a warp stop motion, are in use with the friction type of let-off, which requires frequent manual adjustment by the weaver as the beam weaves down. It must be admitted that this motion, when properly adjusted, is easier on the warp than most of the automatic motions, and that this results in slightly better cloth is a fact that few will deny. But it requires a good deal of attention from the weaver, and, moreover, the lifting of the weights, which are frequently as heavy as 40 lbs., is too much for female labour. It is, without much doubt, only a matter of time before a simple motion will be devised that will act without attention and yet be as easy on the warp as the old friction type.

In addition to being fitted with a weft replenisher, an automatic let-off, and a warp stop motion, the whole construction of the automatic loom must be good, to eliminate, as far as possible, stoppages due to mechanical defects in the loom. For the same reason, the looms must be kept in good repair, and should be oiled and cleaned on a regular system. The drive of the looms must be as steady as possible to prevent the loom knocking off due to irregular speed of driving.

A study of the results of tests on the causes of loom stoppages reveals the fact that many of these stoppages are due to preventable causes, and such stoppages must be eliminated. The cone overpick, owing to the necessity for frequent oiling of the picker spindle, is not a very satisfactory motion for automatic looms. The cone underpick, which is frequently used, is probably the best type for this work.

An objection has often been raised against automatic looms—and as often refuted by the makers and by many of the users of these looms—that they require a better quality of warp and weft than ordinary looms. Without doubt, it sometimes happens that warps are met with that give trouble due to the warp stop motion of the automatic loom that would weave fairly well in the ordinary loom, but such cases are rare, and, generally speaking, a warp that will weave without excessive breakages in an ordinary loom will weave satisfactorily in an automatic one. And similarly with weft. But it is more than likely that any better quality of yarn that may have been found desirable for the automatic loom would have given advantages in the ordinary loom, in the shape of a higher production and a better cloth, that would have more than balanced the extra cost of the yarn.

A less-controversial point is that yarns for the automatic loom should get better preparation than is often considered sufficient for yarns for the ordinary loom. For warp yarns this probably means only careful work at each stage of the preparation, every care being taken at winding, warping, sizing, and looming to produce a warp as perfect as possible. Ring-spun weft is undoubtedly more suitable for automatic weaving, on the cop-changing system, than mule weft, and consequently automatic looms on that system show to the best advantage in mills where both spinning and weaving are carried out. Ring frame weft can be spun on special bobbins, suitable, in the case of cop-changing looms, for direct use in the shuttle, the bobbins being rather larger than ordinary weft bobbins so that they hold a good length of weft, and so wound at the base that with a good feeler motion the weft is used to within a few yards of the end. Mule-cop weft can be used, both in shuttle-changing and in cop-changing looms, special skewers being used in the latter. But weft so used is liable to be badly skewered, and it is difficult to prevent some considerable amount of waste due to breakages and to varying amounts left on the cop bottom. Also, the stoppages due to weft failure may seriously lower the efficiency of the loom, or reduce very considerably the number of looms per weaver. Rewinding of the weft on to pirns or paper tubes is often resorted to in order to improve the running of the looms, and there is much to be said for this from the point of view of higher weaving efficiency, but the rewinding of the weft is a very expensive process and increases the cost of the weft by at least 1d. to 2d. per lb. For coarse weft, where it is desirable to get as much into the shuttle as possible, and also for very fine weft, which would normally be used in good quality cloth with a better margin of profit than the commoner sorts, rewinding is profitable, but for medium counts it is very questionable whether the gain at the loom balances the extra winding cost. Ring-spun weft does not call for rewinding to the same extent as mule-spun, and hence has a decided advantage. Mule weft, however, is often preferred, and usually makes better cloth than ring-spun weft. But if the cloth with ring-spun weft is ghtly cheaper than that with mule weft, the former would generally be hosen.

The organisation of labour for automatic weaving generally differs from that for weaving with ordinary looms. Since the chief advantage of the automatic loom lies in the reduction of weavers' wages, and since the weaver is a highly skilled worker, it is desirable to limit the weaver's work to those operations which require considerable skill and to provide other labour for the less-skilled parts f the work, such as carrying weft from the store to the looms and replenishing he batteries. Again, the mechanism of the loom is rather more complicated than that of the ordinary loom, and some trouble has been caused through overlookers or tacklers failing to keep this mechanism in the best working condition. The average tackler has not always had a proper training as a mechanic or been properly instructed in the mechanism of the automatic loom, and unless he has had the benefit of both of these trainings he cannot be expected to be very successful in carrying out adjustments on automatic looms.

CHAPTER III

COP-CHANGING MECHANISM—THE NORTHROP SYSTEM

The Northrop weft-replenishing mechanism is simple and effective. The weft, on ring bobbins, or rewound pirns or paper tubes, or in mule cop on special skewers, is placed in a circular battery or magazine, as shown in figs. 1 and 2. The bottom bobbin or pirn occupies a position immediately above the shuttle when the latter is in the box at the battery side and the slay in its forward position. From this position the new bobbin is forced into, and the old bobbin out of, the shuttle when the feeler or weft fork decides that weft renewal shall take place. Change by weft fork can be used when broken picks are permissible, and this, of course, means that the loom never stops for a weft breakage, any partly emptied bobbin that has been changed being again placed in the magazine. But if the weft fork acts through failure of the new bobbin to thread properly, the loom is stopped after three successive transfers and failures to thread. The motive force for operating the changing hammer or transfer fork (fig. 2) comes from the slay, on which a wedge-shaped bracket or "bunter" is fixed so that it comes in contact with a notched bunter lever, when the latter has been allowed to lift into the changing position through parts set in action by the feeler.

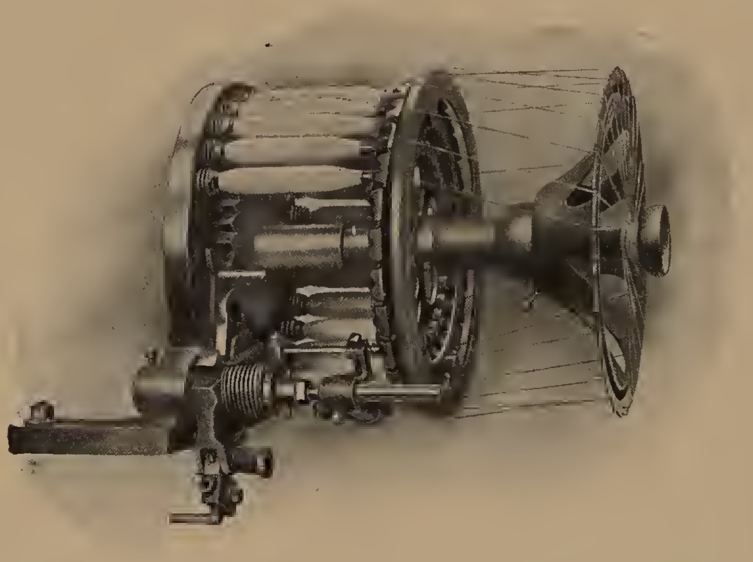

Fig. 1.—Northrop Battery for Ring Frame Bobbins.

Before transfer actually takes place, a shuttle protector moves across the slay at the entrance to the shuttle box. This protector prevents a change if the shuttle is not far enough home in the box. If the shuttle is correctly placed, a cutter blade on the protector cuts the old weft, but holds the end of the piece left between the selvedge and the cutter, retaining it, with the help of a gripper, until after a few picks this piece of weft, together with the end of new weft, is cut within about half an inch of the selvedge by a second cutter in the temple. The ends of the wefts from the bobbins in the magazine are wound round the magazine arbor as shown in fig. 1. After the transfer of the bobbin, the end of the new weft remains attached to this arbor, and this weft is cut, as stated, when it reaches the cutter in the temple. Thereafter the movement of the magazine, as it turns after successive transfers, gradually winds the length of weft on to the arbor, from which the waste is periodically removed. On the first crossing of the shuttle after a new bobbin has been inserted, the new weft half-threads itself into the self-threader of the shuttle (fig. 3), the threading being completed on the return journey of the shuttle, which draws the weft properly into the eye of the shuttle.

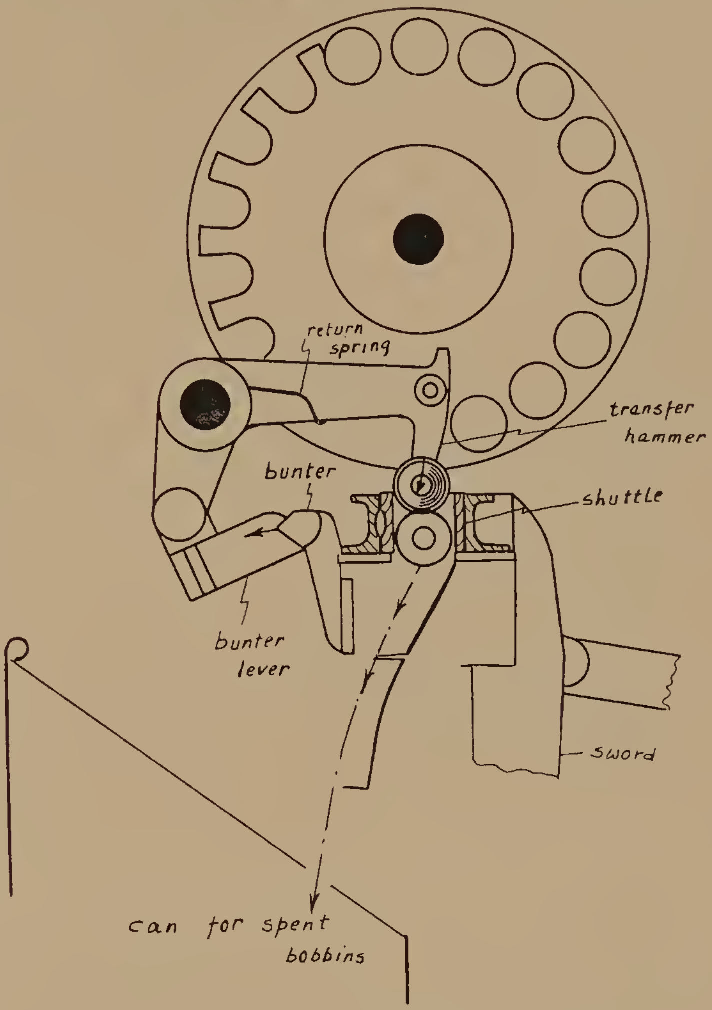

Fig. 2.—Section of Northrop Battery.

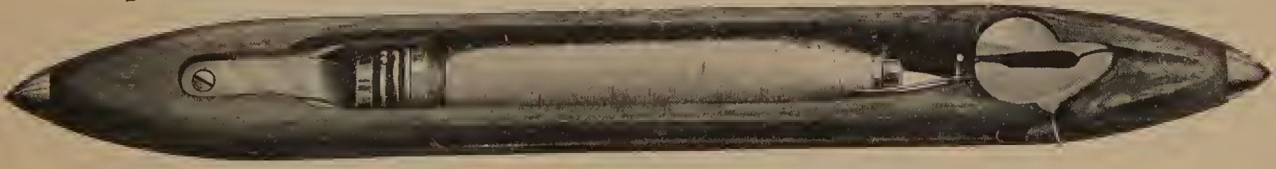

Fig. 3.—Northrop Self-threading Shuttle.

The circular magazine is normally controlled by a ratchet wheel, clearly seen in fig. 1. The ratchet pawl is attached to the transfer hammer, and as the latter moves up after a change the ratchet turns one tooth and brings the next pirn into the changing position. A retaining pawl is provided, and the pawls can readily be thrown out of action so that the magazine can be turned back by hand for convenience during filling. The outer disc of the magazine is adjustable, to enable the best angle of the thread to be got for effective threading-up.

The transfer hammer is shown in figs. 1 and 2. It is normally kept up above the pirn by means of a coiled spring, which serves also to lift it back to this normal position after it has changed a bobbin. The notched bunter lever, which is hinged on the tail of the hammer lever, is normally kept down, as shown in fig. 4, by a projection attached to the positioner or protector. A coiled spring, however, is always trying to lift this bunter lever, and does so when the protector has moved forward before a change.

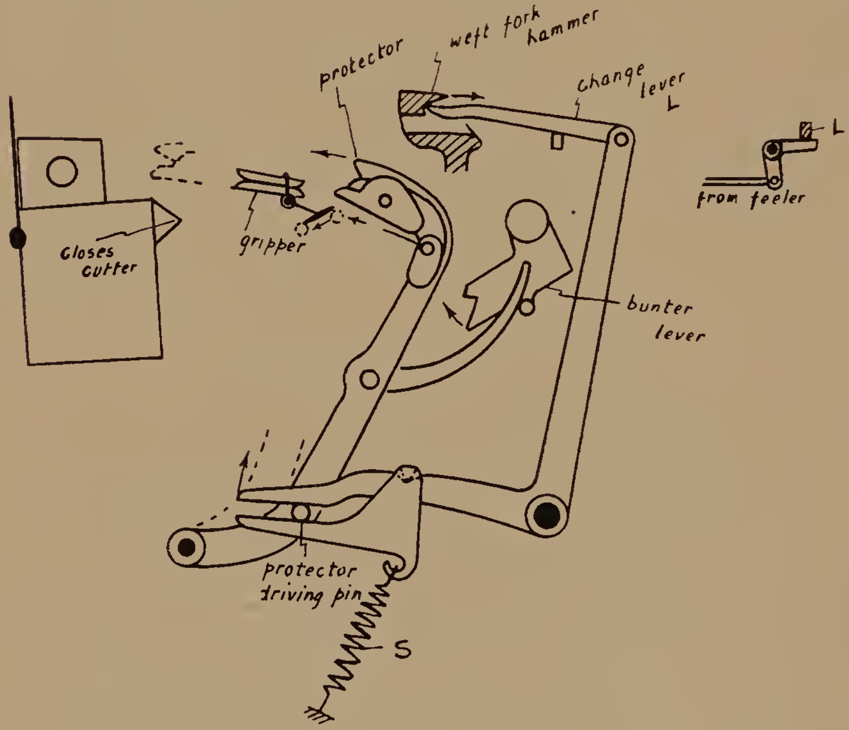

Fig. 4.—Northrop Shuttle Protector and Thread Cutter.

The weft-fork hammer is used to set the changing parts in action. When a feeler is used, the weft fork acts in the usual way on the starting handle of the loom and stops the loom on the failure of the weft. But, in addition, the weft-fork hammer is used, through the medium of parts shown in fig. 4, to move the protector and allow the bunter lever to rise. The parts are shown just beginning to move, the feeler having lifted the change lever L to engage with the weft-fork hammer, the forward movement of which results in the movement of the protector towards the slay, a movement which is accompanied by the rising of the bunter lever. The protector is driven forward through the medium of the protector driving pin, the spring S keeping the triangular piece to which it is attached pressing against the driving pin, following up the movement of the lever above it, the triangular piece being suspended on the lever by a knife-edge pivot. The spring S also serves to return the parts to the normal position after the change, and further, it allows the protector to stop in its forward movement if it strikes the shuttle, through the latter being incorrectly boxed. If this happens, the bunter lever cannot complete its upward movement and it does not meet the bunter, so that no change takes place; but on the return of the shuttle to the magazine side, after the feeler has again set the change parts in action, the change takes place if the shuttle is now correctly boxed. If not, the loom probably knocks off through the fast reed motion, or the weft becomes exhausted, and the loom is stopped by the weft fork. These parts are shown in fig. 5, which shows the protector nearing its forward position, "feeling" if the shuttle is in the correct position for the transfer of the weft bobbin. The cutter is opening, ready to cut the weft of the nearly empty bobbin. If the shuttle is almost, but not quite, correctly boxed, the protector, acting on the shuttle nose, pushes the shuttle far enough into the box to allow of the change taking place.

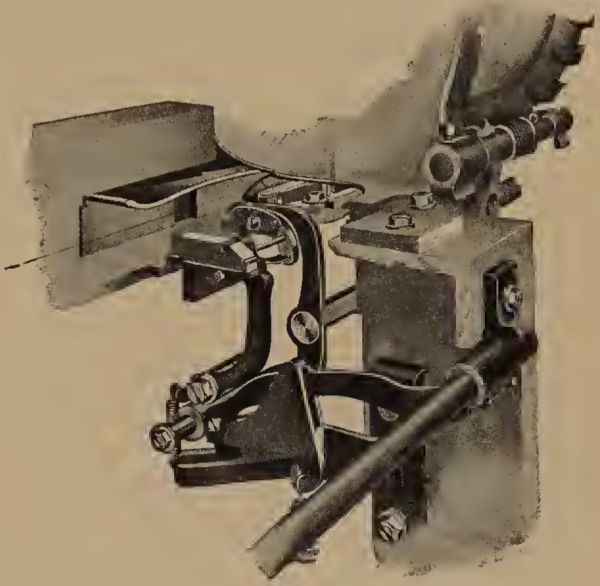

Fig. 5.—Northrop Shuttle Protector and Thread Cutter.

The feeler is placed at the opposite side of the loom to the magazine and should operate when only a few picks of weft are left on the pirn. The feeler for the ordinary single-shuttle loom is a mechanical one, generally working on the "side-sweep" principle, and one of the latest type is shown in fig. 6. The blade of the feeler, which is shown after it has made its side-sweep movement to the right, enters the shuttle through a slot in the shuttle side, and the serrated feeler-end comes in contact with the weft as the slay beats up. So long as weft is present the feeler blade is moved straight back, but as soon as the weft is exhausted the blade swings sideways as shown in the illustration, and this side movement is used to move a small bell-crank lever, one arm of which lifts the change lever into contact with the weft-fork hammer. The feeler is mounted on a small lever which is always tending to swing sideways into the position shown, under the action of the spring on the right of the feeler casing. Normally this side movement is prevented by the Z-shaped piece and the spring threaded on the plunger rod on the left of the casing, this spring being stronger than the other and capable of moving the feeler lever back to its normal position. Near the beat-up the shuttle edge comes in contact with the plunger head, moving it back about $\frac{3}{16}$ inch and releasing the feeler lever. Whether the latter now swings sideways depends on whether the serrated blade is in contact with yarn on the bobbin. If it is, the yarn prevents the movement and the feeler blade moves straight back, the spring on which it is mounted yielding to allow the movement. But if the bobbin is bare, the feeler meets with no resistance on the smooth bobbin surface and swings over to effect the change. A small bunch of weft is wound at the base of the bobbin or pirn, as shown in the figure, the bunch containing enough yarn for two or three picks, to enable the shank of the bobbin to be entirely bared without risk of stopping the loom through the weft running out before the change. This bunch is somewhat troublesome to wind, and sometimes it is dispensed with, especially when rewound pirns with a conical head are used, the feeler being set to leave one or two coils on the bobbin. Sometimes a fairly deep groove is turned in the pirn head, near the base of the cone, and this, filling up during the traverses when winding, serves the same purpose as the bunch, without needing the special bunching mechanism. It is almost, if not entirely, impossible to set the feeler to leave a bare shank every change with cone-base bobbins, as the position of the bobbin in the shuttle may vary slightly, according to which of the grooves in the spring jaw engage with the rings on the bobbin head when the bobbin is forced into the shuttle.

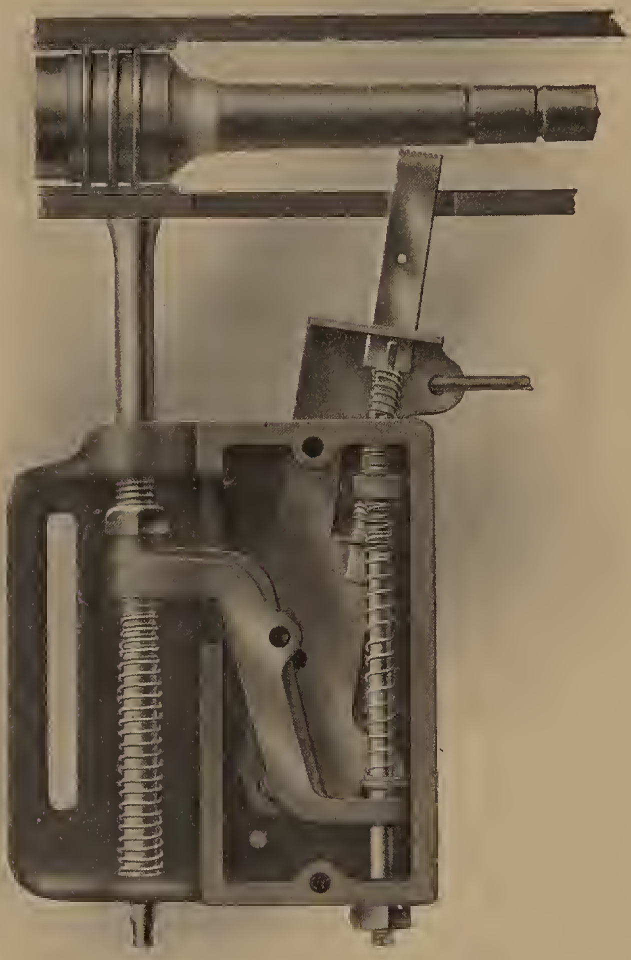

Fig. 6.—Northrop Side-sweep Feeler.

The great advantage of the side-sweep feeler over earlier types is that once the feeler blade is free to move it moves decisively, with its complete movement, and there is no wearing away of the contact parts between change lever and hammer head, such as occurs when these contacts gradually come together and frequently make several false contacts before finally engaging together.

The cutting of the old weft before the transfer is one of the most important and one of the most difficult operations in cop-changing looms. If, on the one hand, the cutting is not effectively done, the thread will almost certainly remain in the shuttle eye when the bobbin is ejected, instead of the cut end being drawn clear of the shuttle by the fall of the bobbin. When the shuttle is picked across after the change, if the old weft is still in the eye of the shuttle, it is carried back into the warp shed together with the new weft. Generally the old weft breaks at or near the cutter, and the result is a double pick, extending part way across the cloth. On the other hand, if the weft is cut properly, but the end of the piece between selvedge and cutter is not firmly held by the cutter and gripper, there is a great risk of this length of old weft being drawn in by the shuttle, again resulting in a partial double pick. This is a matter of great importance, as the cloths that are woven with the feeler are normally such that faulty picks of this kind are not permissible. The trouble does not arise when a change is effected by the weft fork, for there is no old thread to cut, and no thread cutter is required on the protector. But the weft-fork change is, of course, only suitable for cloths in which faulty picks are permissible. The arrangements for cutting and holding the weft are more extensive in the Northrop loom than in most cop changers, but even so the troubles mentioned are not infrequent.

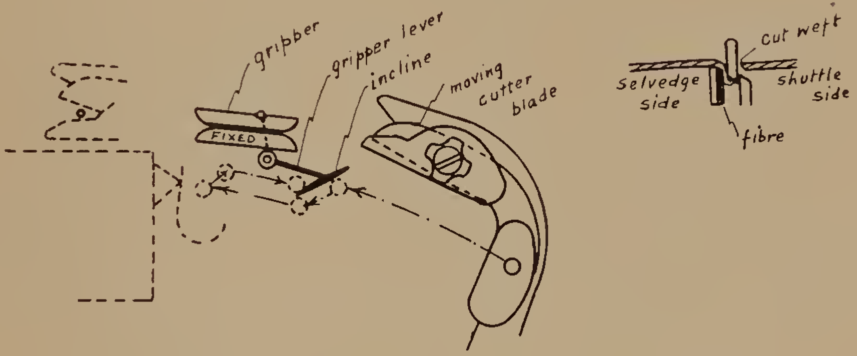

Fig. 7.—Northrop Thread Cutter.

The cutter blade on the protector (fig. 7) is opened, as the latter swings forward, by a pin on the rear end of the cutter blade striking and being deflected by the underside of a small incline fixed to the gripper lever. The weft thread enters the open jaw of the cutter, and the latter is closed by a bracket on the slay with which the cutter tail comes in contact. This should sever the thread on the side of the cutter nearest the shuttle, the end of the piece coming from the selvedge being held by the closed cutter jaw (see section detached). As the protector moves back, the pin on the cutter tail should strike the top side of the incline on the gripper lever, and in so doing should open the gripper to receive the thread, the top grip closing lightly on the thread by the action of a spring after the pin has cleared the incline. The thread end should still be held by the cutter in addition to the gripper, and should only be released from the cutter when the latter is opened on its next forward movement. To prevent the thread end from being drawn out of the cutter after the gripper has closed, the protector is caused to move slightly inwards, towards the cloth, for the last part of its backward movement. This is shown by the diagram in fig. 8, which also shows the position of the temple cutter. The latter is a simple cutter blade which is moved down and away from the reed at every beat-up, through the action of

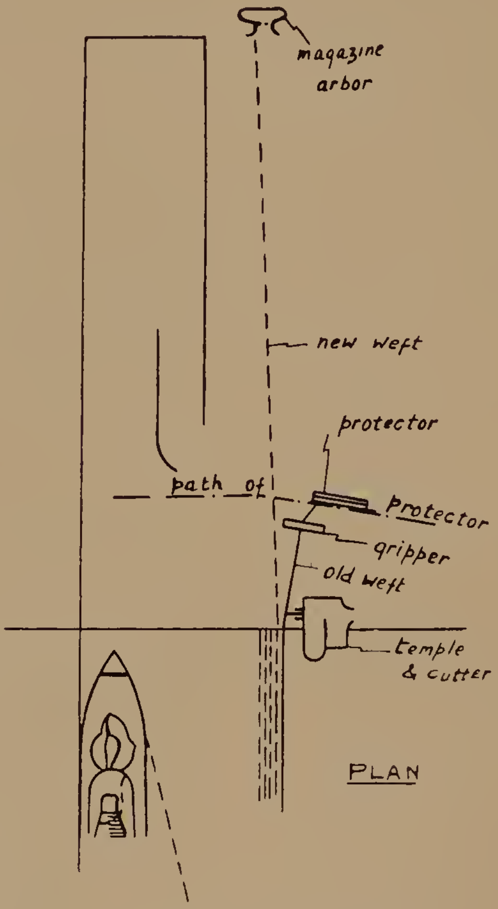

Fig. 8.—Diagram showing the Action of Northrop Weft Cutters.

a tail on the cutter blade meeting the slay. This action of the cutter blade makes it catch the two weft ends when they come within its reach, and as it moves back between two fixed blades it cuts the weft.

CHAPTER IV

SHUTTLE-CHANGING LOOMS

SHUTTLE-CHANGING looms are of many types, but the most successful appear to be those which are automatically stopped when the weft is exhausted, or nearly so, and automatically restarted after the empty shuttle has been ejected and the full one inserted. Of this type, typical looms are the Stafford and the Hattersley. The former has been manufactured in America, but it is now being made also, as the Vickers-Stafford loom, by Messrs Vickers (Crayford), Ltd., Crayford, Kent.

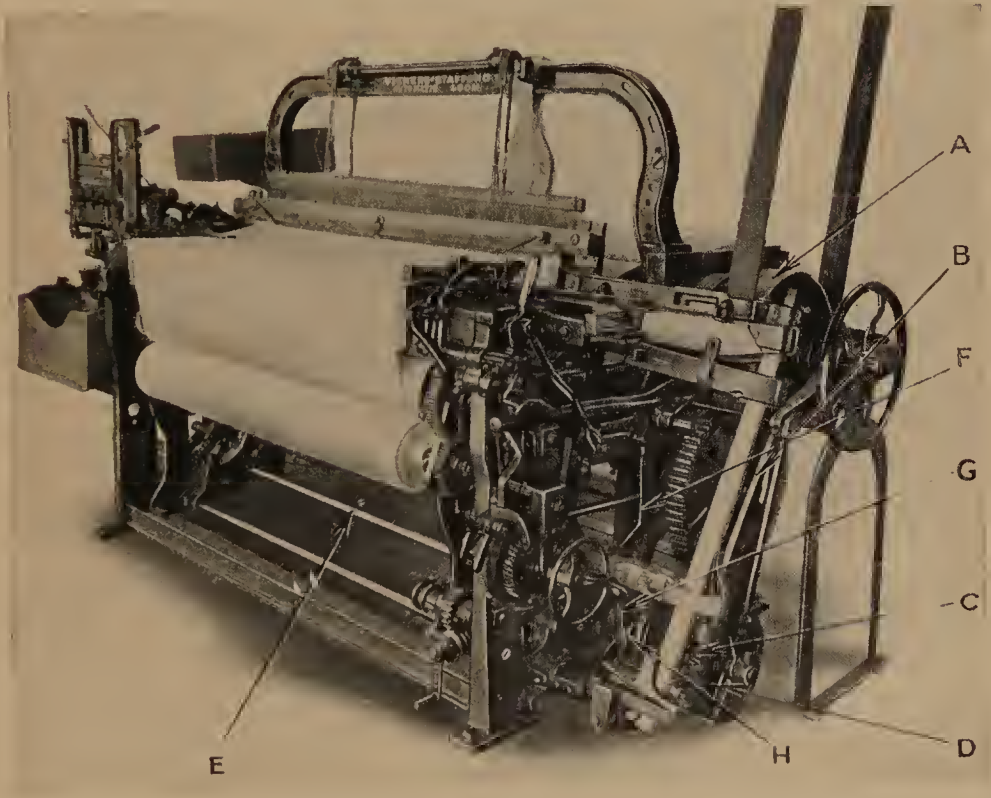

FIG. 9.—VICKERS-STAFFORD LOOM—DRIVING END.

In both of these looms—the Stafford and the Hattersley—the general sequence of operations and the method of carrying them out is the same, but the arrangement of the parts and the general construction of the looms differ widely. In both, a vertical stationary magazine is used, holding normally about ten shuttles. When the weft fork or feeler puts the change mechanism in action, it automatically stops the loom with the crank near the back centre and the shuttle at the magazine side. A cam shaft is now set in motion, and the cams complete the various movements. The shuttle-box front is lifted, the shuttle pushed out from behind and allowed to fall gently into a box under the slay end, the bottom shuttle in the magazine is lowered on to a conveyor, which then carries the shuttle to the shuttle box, leaves it in place, and returns to its position under the magazine. After the box front has been lowered, the cam shaft stops and the loom is automatically restarted, the whole operation taking about three seconds.

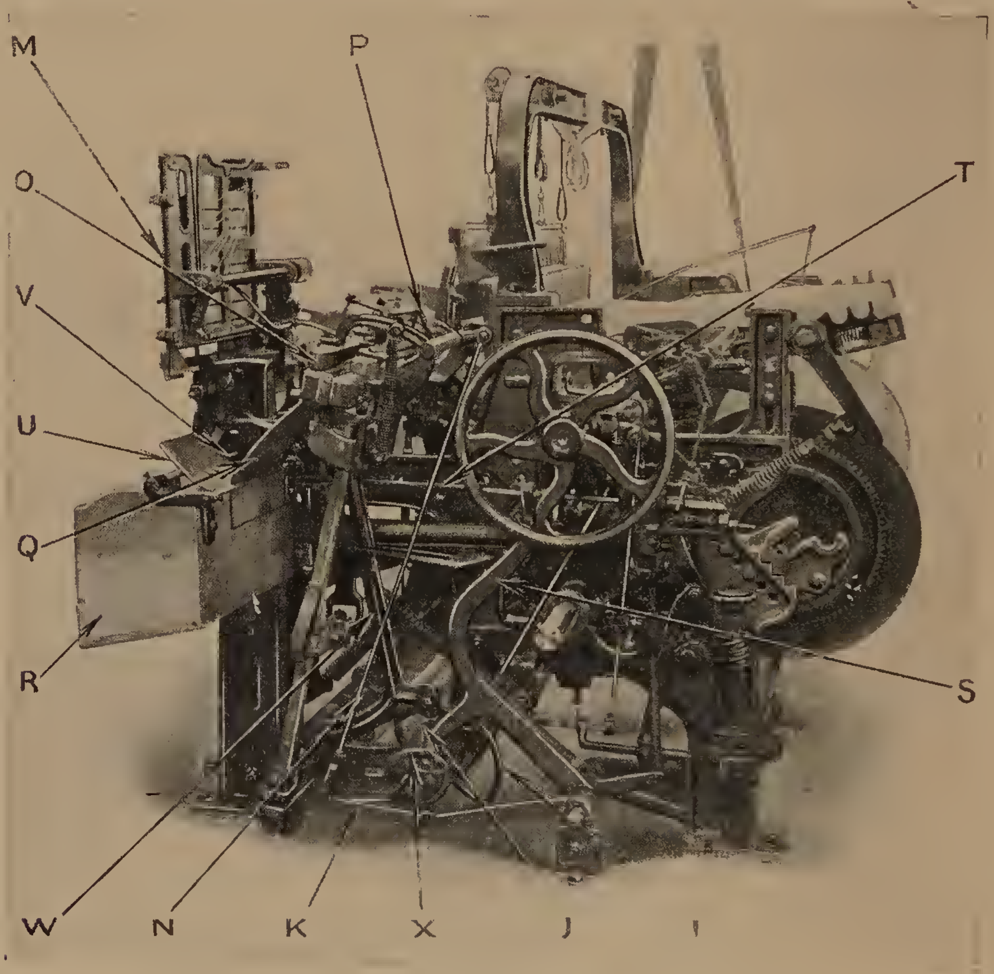

Fig. 10.—Vickers-Stafford Loom—Magazine End.

Stafford Loom.—In this loom the driving pulley, usually of the friction type, is at the opposite end of the loom to the magazine. The driving end also carries the feeler motions, the brake, the drive to the cam shaft, and the uptake motion, leaving the magazine end free for the shuttle-changing parts, together with the warp stop and let-off motions. Distributing the mechanism in this way necessitates the carrying of the cam shaft from one end of the loom to the other, but it has the decided advantage of not overcrowding the mechanism and leaving all the parts readily accessible. This will be evident by examining figs. 9 and 10, which show respectively the driving and magazine ends of the loom, the latter in particular showing the simple nature of the shuttle-changing parts. Since it is necessary that the loom should always stop in approximately the same position, the brake motion must be efficient. In this loom the brake is in the form of a shoe, provided with cork insets, and this brake is applied to a wide brake pulley whenever the starting handle is thrown off and the clutch disengaged. Provision is made, however, for releasing the brake when the loom is being turned over by hand.

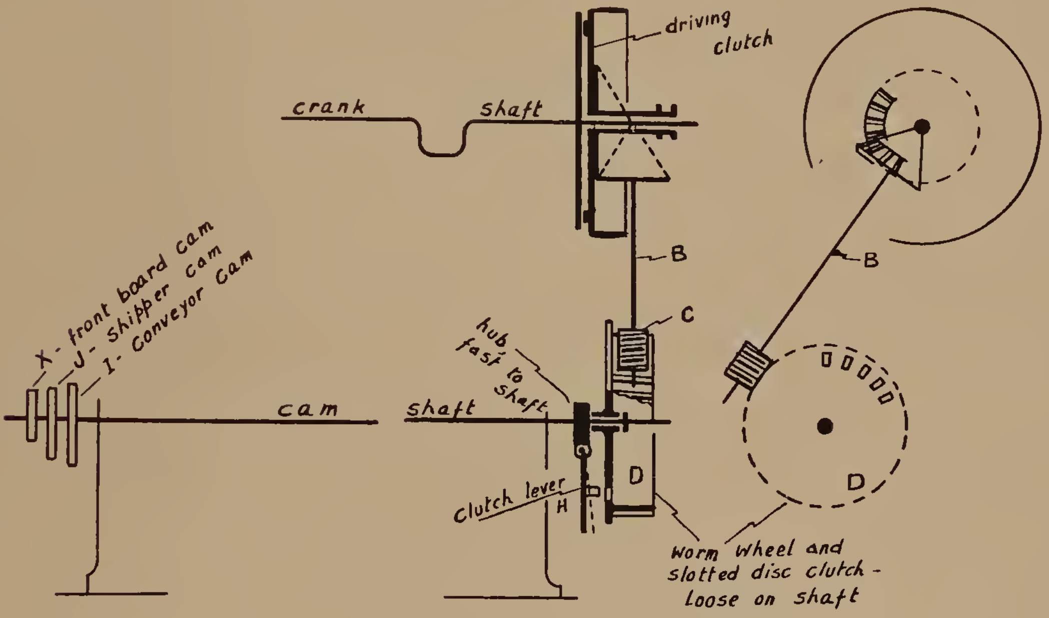

Fig. 11.—Stafford Loom—Cam-shaft Drive.

The cam shaft, which operates the shuttle-change motions, gets its movements from the loom crankshaft as shown diagrammatically in fig. 11, and most of the parts shown there can also be seen in figs. 9 and 10, the reference letters being the same in all the illustrations. A bevel wheel and worm drive from the friction driving pulley keeps a worm wheel and slotted-disc clutch D constantly rotating so long as the belt is running on the loom pulley. The disc D is normally loose on the cam shaft E, but when the weft fork or feeler decides on a change, a clutch lever H fixed to the cam shaft is engaged with one of the slots in D, and the latter then drives the shaft. After the cam shaft has made one revolution the clutch lever comes in contact with a cam lever, which disengages the lever from the slotted disc, and the cam shaft stops.

There are three cams on the cam shaft, at the magazine end of the loom, and these three cams are fixed together so that it is impossible for the movements to get out of time with each other. The inner cam operates the shuttle conveyor, the next cam the shipper or starting lever for restarting the loom, whilst the outer cam lifts the box front and also ejects the spent shuttle. These parts are shown in the diagram, fig. 12, which shows the parts in the normal position, ready for a change.

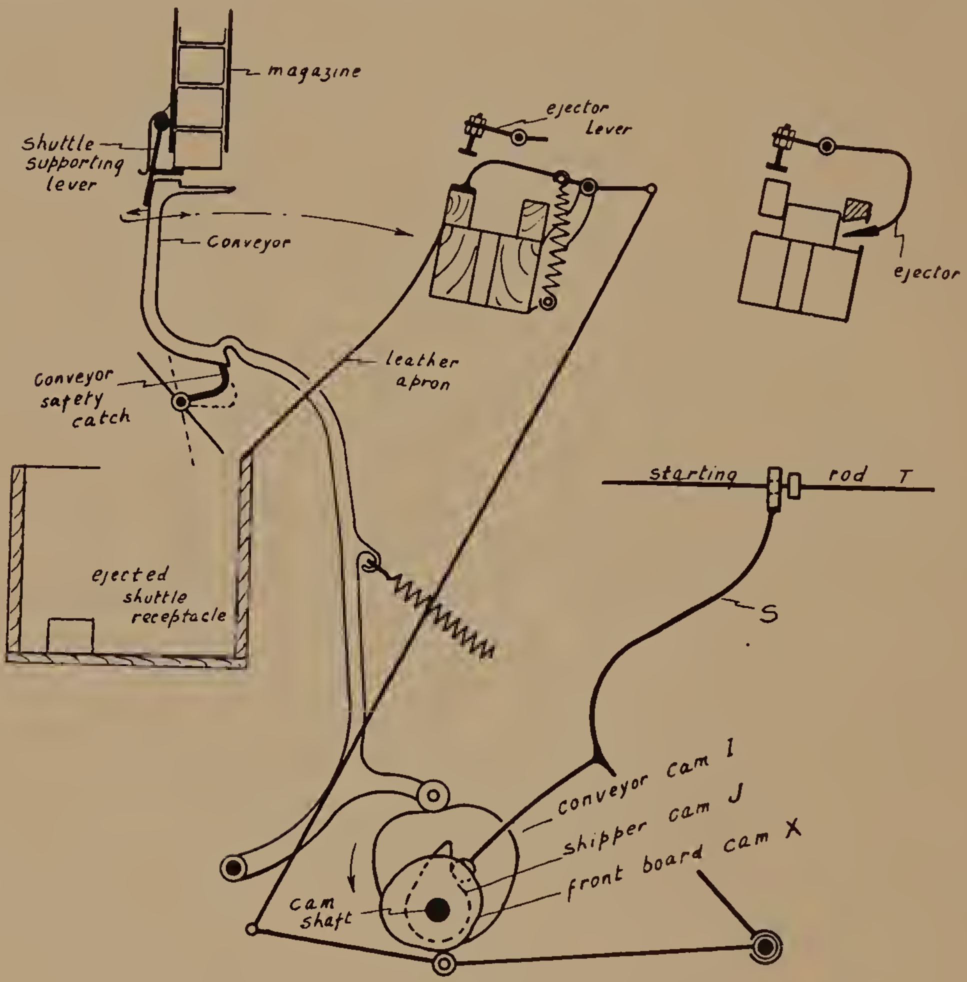

Fig. 12.—Stafford Loom—Diagram of Magazine End.

The rotation of the conveyor cam first moves the conveyor forward a little towards the front of the loom, thus removing the support from the bottom shuttle in the magazine and allowing it to slip down on to the conveyor. At the same time a safety catch enters a notch in the conveyor lever. The conveyor with the shuttle is now ready to move towards the shuttle box, where by this time the box front should have been lifted bodily and the old shuttle ejected, leaving a clear entrance for the new shuttle. As the ejected shuttle slips down the leather apron and enters the receptacle it deflects a light, hinged flap which is attached to the safety catch, and the latter is withdrawn from the notch in the conveyor lever, allowing the latter to move towards the shuttle box under the action of a strong spring. The safety catch effectively prevents the possibility of getting two shuttles in the loom at one time, as a fresh shuttle can only be inserted after one has been ejected. Normally, however, the conveyor carried the shuttle to the shuttle box, the conveyor entering the box with the shuttle, under the lifted box front. The box front is then dropped enough to prevent the shuttle from leaving, and the conveyor is drawn away by its cam, returning to the normal position, whilst the lowering of the box front is completed.

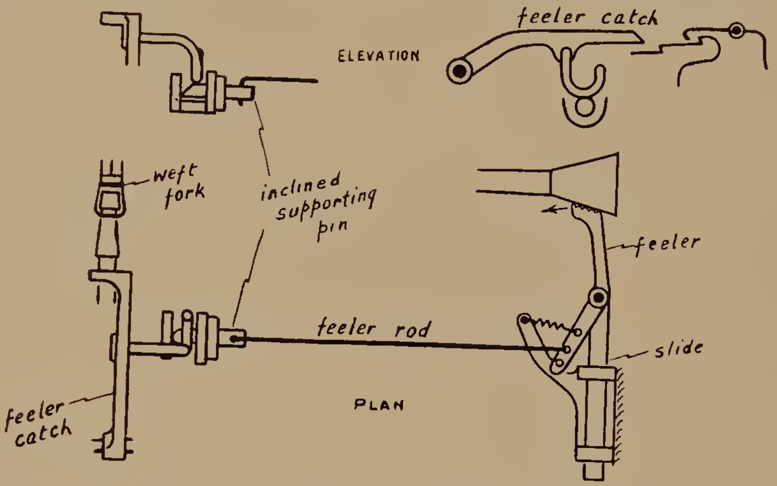

Fig. 13.—Stafford Loom—Side-sweep Feeler.

The front-board or box-front cam lifts the front board through the simple lever connections shown, springs being used for the return movement. The levers and other parts on the box top are substantially made, and whilst the front lifts easily, the parts are quite rigid when the box is closed for weaving. The same cam is used to operate the ejector, the latter also being fulcrumed above the shuttle box. After the box front has lifted sufficiently to allow of the ejection of the shuttle, the rising box front comes in contact with an adjustable tail on the ejector lever, as shown detached, and further lifting of the box front causes the ejector to enter the shuttle box through an opening in the back and to eject the shuttle. The box front then falls sufficiently far to allow the ejector point to get clear of the entering shuttle, but a clear opening must, of course, be left for the shuttle until it is home in the box.

As usual, shuttle change may be effected either through the weft fork or through a feeler. Various types of feeler motion are used, depending mainly on the kind of weft in use and on whether the weft has been rewound or not. For rewound pirns a side-sweep feeler is suitable and is shown in fig. 13. A very light feeler catch is normally kept out of contact with the weft-fork hammer head by resting on an inclined supporting pin which is attached by a rod to the feeler. So long as yarn is on the pirn, the feeler is pushed straight back, but when the feeler blade touches the smooth wood of the pirn head, the pressure from the inclined head on the feeler causes the latter to move sideways and to withdraw the inclined supporting pin, which lowers the catch so that it engages with the hammer head, and the movement so given to the catch is used to throw out the main driving clutch of the loom and to engage the cam-shaft clutch to effect the change of shuttle. Immediately the pressure between the feeler blade and the pirn is relieved, by the backward movement of the slay, a spring attached to the feeler moves the inclined supporting pin back to its normal position. This feeler is very sensitive in its action, the amount of resistance to be overcome by the feeler in making its sideway movement and in withdrawing the inclined supporting pin being very small.

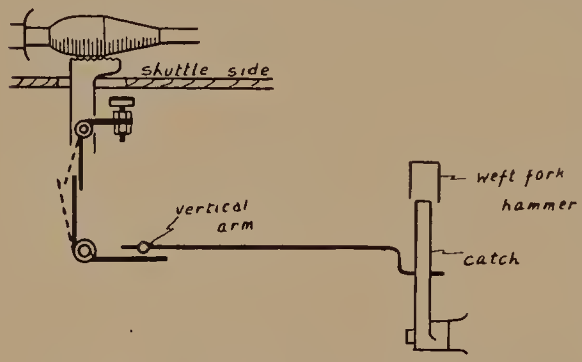

Fig. 14.—Stafford Loom—Feeler for Cop Weft.

Another type of feeler, suitable, for example, for fine cotton weft in mule cops, used on the shuttle tongue, without rewinding, is shown in fig. 14. The feeler blade enters the shuttle as the slay beats up and is pressed back by the cop. When the weft is almost exhausted an adjustable lever on the feeler blade comes in contact with the shuttle side, and the movement so given to the lever is used, through the connections shown, to lift the feeler catch into contact with a notch on the weft-fork hammer head.

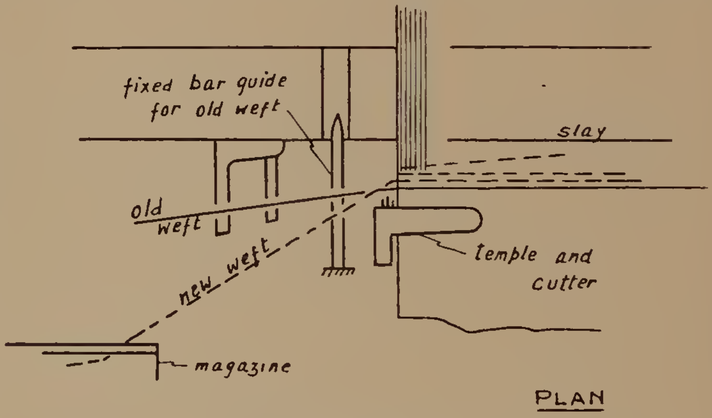

Fig. 15.—Stafford Loom—Diagram showing Weft Cutting.

The arrangement for cutting the wefts after a change is simple, only a single cutter being needed. This cutter is at the side of the temple and is pushed back every time the slay beats up, trapping both old and new wefts after a change, and cutting both within a very short distance of the selvedge. Suitable provision is made for holding the old and new weft taut until cut, and this is shown in fig. 15. A fixed bar guide is placed near the selvedge and parallel to it. This guide is just below the level of the raceboard, which is grooved to receive it, and the shuttle passes over the top of the guide when entering the shuttle box at the magazine side. When the old shuttle is ejected, the weft remains in the shuttle eye and extends from the cloth selvedge, over the guide, directly down to the shuttle in the receptacle. Again, the new weft is attached to the magazine, and by means of suitable guide bars on the latter, the new thread stretches directly from the magazine to the cloth selvedge. Both threads are thus held securely and fairly taut until trapped and cut by the temple cutter. It will be seen that the elaborate precautions necessary on cop-changing looms to prevent the weft ends being dragged into the cloth are not necessary here, and one of the most troublesome faults in automatic weaving is eliminated in the shuttle-changing loom. The cutter is a simple movable blade, which is pushed back at beat-up between two fixed guides, one of which also has a cutting edge. The temple itself is normally right up at the fell of the cloth, and is pushed back about one-quarter of an inch by the reed at beat-up.

THE HATTERSLEY LOOM.[1]—As already mentioned, the general sequence of operations is the same in the Hattersley loom as in the Stafford, but certain differences may be noted. With the exception of the weft fork and feeler, if one is used, all the changing mechanism is concentrated at the driving end of the loom, the cam shaft, together with its clutch box, being placed almost directly below the shuttle box. This has the advantage of keeping the space underneath the cloth clear of the cam shaft, and leaving it free for the fitting of heald reversing motions, etc., an advantage which may be worth while for certain dobby and positive tappet looms, but for the majority of looms the fact that the cam shaft passes through this space is very little detriment, as an examination of the Stafford loom, shown in fig. 9, will show.

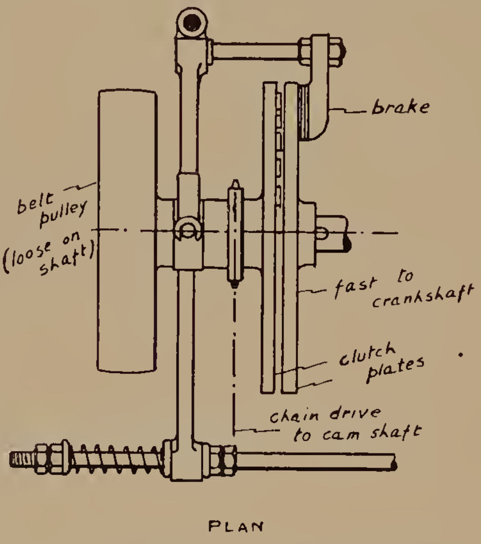

FIG. 16.—HATTERSLEY LOOM—DRIVING PULLEY AND BRAKE.

The drive is generally through a friction clutch plate, with cork insets, working in conjunction with a brake which acts on the back of the driven friction plate when the clutch is disengaged. It is not possible, with the driving gear as generally fitted, to release the brake without at the same time engaging the clutch and driving the loom, and hence turning the loom by hand is a very difficult operation, as the brake friction has to be overcome. This difficulty can be got over by a special device on the starting handle, which allows the latter to be placed in a position midway between the "off" and the "on" positions, the result being that the brake is released without engaging the clutch. The arrangement of the drive is shown in fig. 16.

Five cams are fitted to the cam shaft, one for lifting the box front, one for the shuttle ejector, a third for operating the shuttle conveyor, a fourth for lifting the restarting lever for starting up the loom after a change, and the last a locking cam, which is made with a recess into which its spring-loaded antifriction roller slips, on the completion of the cam shaft revolution, and which prevents further movement of the cam shaft until another change is required. The cam shaft is provided with a driving clutch working on the same general principle as that on the Stafford loom, the loose half of the clutch always running so long as the loom belt is running. This part of the clutch is provided with a series of slots into one of which a driving pin is inserted through the action of the weft fork or feeler at the same time that this action disengages the main driving clutch and stops the loom by the brake. The driving pin fixes the cam clutch to the shaft, and the latter makes one revolution, the driving pin being automatically withdrawn from the slot on the completion of the movement.

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[1] For a full description of the Hattersley shuttle-changing loom see *Jute and Linen Weaving*, by Woodhouse and Milne (Macmillan, 1914).

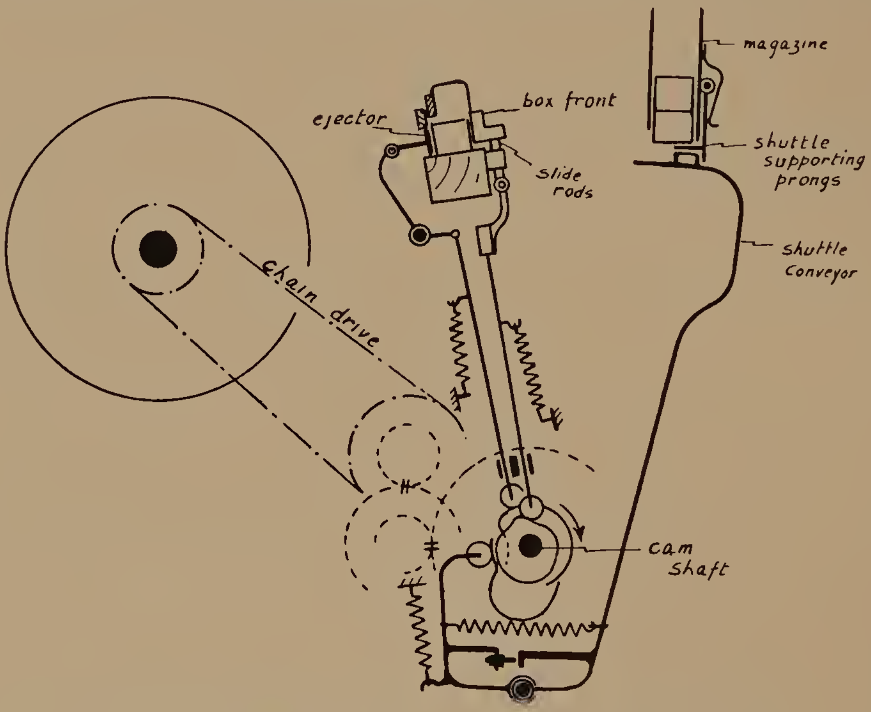
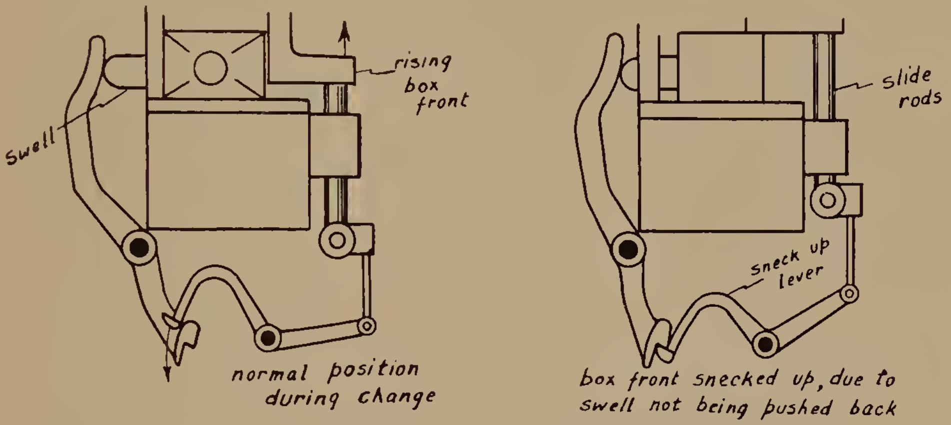


Fig. 17.—Hattersley Loom—Diagram of Magazine End.

The loom is stopped during the change for a period extending to about the time for eight picks, or about three seconds at a loom speed of one hundred and sixty picks per minute; this loss amounts to only about one per cent. in the running efficiency of the loom.

The shuttle-box front is mounted on two slide rods, which work in suitable guides, and the box front is given a parallel lift by its cam. The box front is also connected to and lifts a back slip at the box back, this slip, when down, preventing the shuttle from lifting in the box. The ejector works independently of the box front, the ejector cam being timed to eject the shuttle just after the box front has been lifted. The box front is positively lifted by its cam and returned by spring action (see fig. 17); the ejector pushes out the shuttle by means of a spring and is positively withdrawn by its cam, the spring in each case providing a yielding point if any unusual obstruction is met. The mounting of the box front on slide rods leaves the top of the box clear so that a cone overpick can be fitted. This type of picking motion is necessary, with the motion as arranged, since the space below the shuttle box is occupied by the cam shaft. The slide rods are somewhat objectionable, since the shuttle has to be ejected between them, and the inner one prevents the old weft from being taken quite clear by the falling shuttle. The cut end is liable to remain below the box front, and some of it may finally be drawn into the cloth.

The action of the conveyor is similar to that in the Stafford loom and can readily be followed from fig. 17, spring connections again being used to give way in case of a jam. A safety device is provided to prevent the loom from restarting automatically if the box front does not drop, due, say, to the shuttle being trapped, and another prevents restarting as soon as the last shuttle is taken from the magazine. The loom can, however, be started by hand, and the magazine replenished with the loom running. Provision is made for preventing the swell, which is in the box back, from acting on the shuttle as the conveyor pushes the latter into the box. As the box front rises for the change, a connection from the rising cam rod pushes a sneck-up lever behind the stop-rod finger, which ought then to be in the out position if the old shuttle has been properly boxed, and the stop rod in this way is held out whilst the transfer of shuttles is taking place (fig. 18). If, however, the shuttle has not been properly boxed, the stop-rod finger will not have been forced out by the swell, and the sneck-up lever passes in front of the stop-rod finger. This snecks up the box front, preventing it from falling and the loom from restarting. This device also prevents a new shuttle from being put in the box before the old shuttle is ejected. If, for example, the loom is stopped, with the shuttle at the feeler side, and if the change motion is started by hand, then the sneck-up motion keeps the box front from falling and the loom from restarting. Although the conveyor will



normal position during change

box front snecked up, due to swell not being pushed back

FIG. 18.—HATTERSLEY LOOM—BOX FRONT SNECK-UP MOTION.

place a new shuttle in the box, the shuttle will not remain there because of the lifted box front and the swell projecting into the box.

The weft cutter for both new and old wefts is a simple slide cutter working in the side of the temple, as shown in fig. 19. A few picks after the change the wefts are caught by this cutter, which, as it is pushed back by the slay at beat-up, severs the wefts almost at the selvedge.

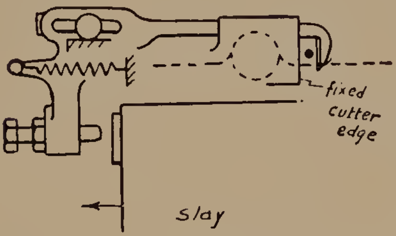


Fig. 19.—Hattersley Loom—Temple Thread Cutter.

The Hattersley Weft-mixing Loom.—The Hattersley shuttle-changing loom can be fitted with a two-shuttle weft-mixing motion. A continuously acting, rising and falling, two-box motion is fitted at the feeler side of the loom, the boxes being moved positively by an interrupted gear-wheel drive from the bottom shaft of the loom. On alternate picks the gear wheel causes a crank to make a half revolution, the movement of the crank being conveyed by levers to the boxes, which are thus lifted and lowered to give two picks from one shuttle, followed by two picks from the other. This is the usual picking, but by altering the drive to the crank the boxes may be moved to give four and four picking.

A double feeler is used, and is mounted on the back of the shuttle box at the double box side. As the boxes move up and down, the movement is utilised cause one feeler blade to enter the shuttle that is brought into use, whilst the feeler is withdrawn clear of the second shuttle. If the weft is nearly exhausted in the shuttle that the feeler enters, the feeler sets the change mechanism in action, and the shuttle is changed for a fresh one from the magazine, after the shuttle has been picked across from the feeler side to the magazine side.

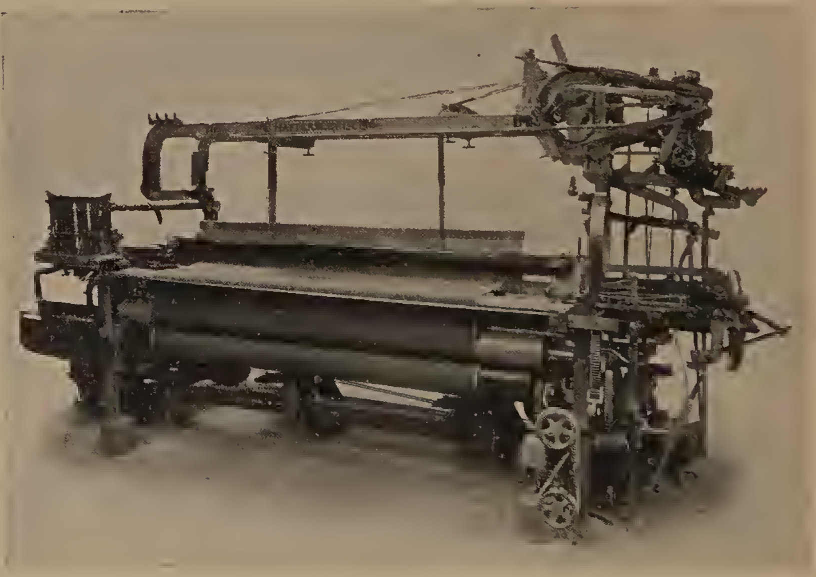


Fig. 20.—Hattersley Weft-mixing Coating Loom.

The changing mechanism used on this loom is exactly similar to that for the single shuttle loom, the only change in the automatic mechanism being in the double feeler motion instead of a single one to put the changing clutch in action when a new shuttle is needed. An illustration of the loom is given in fig. 20, which shows a loom suitable for woollen or worsted coatings and similar fabrics, weft mixing being required to a greater extent in woollen than in cotton weaving. Weft mixing is also very necessary when using artificial silk weft, and a shuttle-changing automatic loom fitted with a two-shuttle motion of the kind described is much more suitable than the single shuttle type for weaving artificial silk or mixed fabrics.

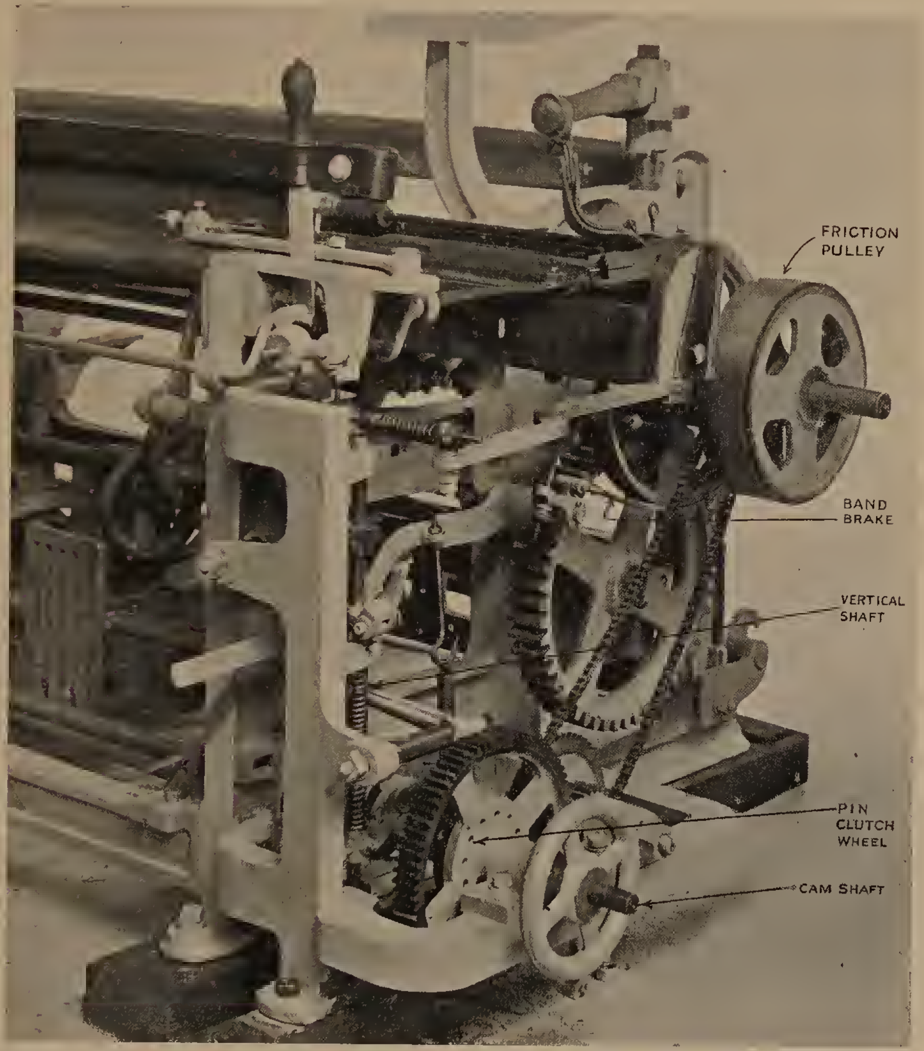


Fig. 21.—Urquhart Lindsay Loom—Driving End.

The Urquhart Lindsay (Walter Patent) Jute Loom.—An automatic loom embodying the Walter patent, and built specially for jute weaving, is made by Messrs Urquhart Lindsay & Robertson Orchar, of Dundee. This, again, is a shuttle-changing loom, which stops whilst the shuttle transfer is taking place, the empty shuttle being ejected, and the new shuttle inserted by a carrier, before the loom is restarted. The driving and magazine ends of the loom are shown in figs. 21 and 22, and these show how accessible the various motions are for any necessary adjustments.

The shuttle change can be controlled from a feeler motion, but in the loom illustrated the weft fork is used to bring the automatic motion into action. When the cop is exhausted, the weft fork is not raised, and the spring set-off handle is released, which stops the loom while shuttle change is taking place. The release of the set-off handle also brings into action a band brake, which checks the momentum of the moving parts and ensures the stopping of the loom with the slay full back, which is the changing position.

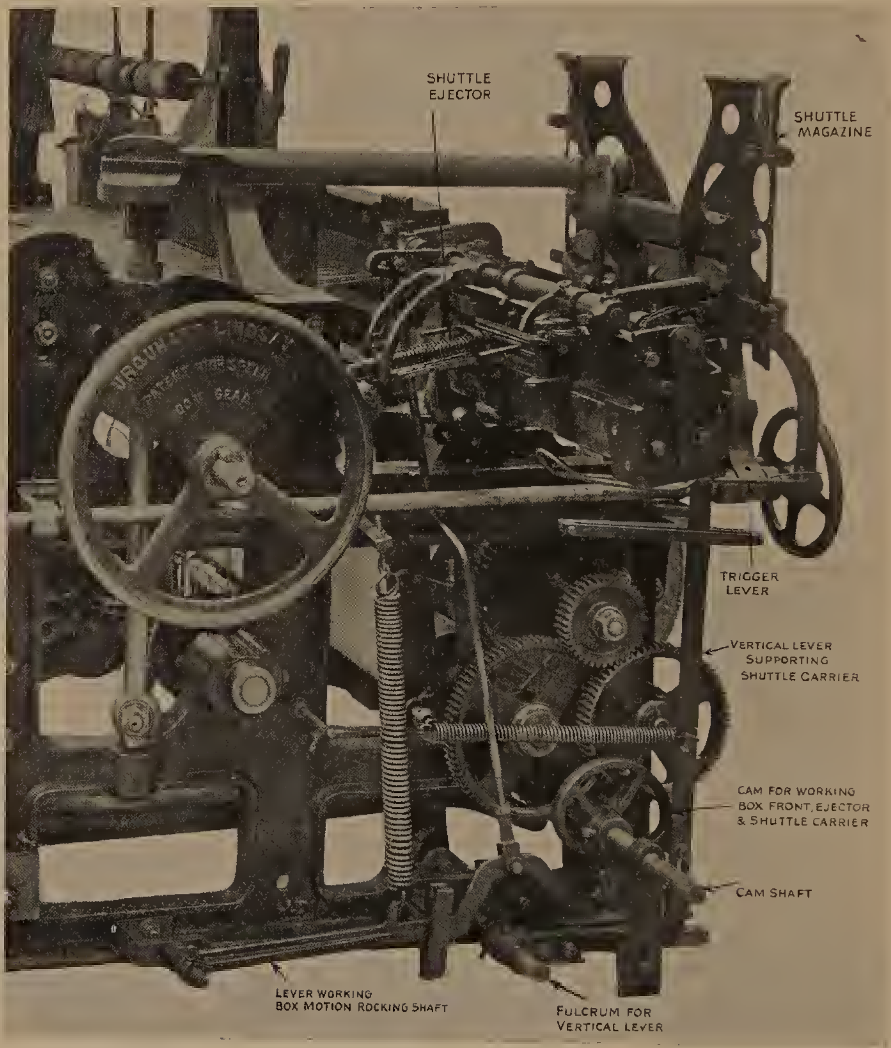

SHUTTLE EJECTOR
SHUTTLE MAGAZINE
TRIGGER LEVER
VERTICAL LEVER SUPPORTING SHUTTLE CARRIER
CAM FOR WORKING BOX FRONT, EJECTOR & SHUTTLE CARRIER
CAM SHAFT
LEVER WORKING BOX MOTION ROCKING SHAFT
FULCRUM FOR VERTICAL LEVER

FIG. 22.—URQUHART LINDSAY LOOM—MAGAZINE END.

The shuttle magazine and feeler motion is placed on the opposite side of the loom to the friction driving pulley, and is worked by a cam shaft which is placed directly below the cloth roll. On this cam shaft a pin-clutch wheel is mounted and is driven by chain and reduction gearing from the main friction pulley. This pin clutch comes into operation when the weft-fork lever stops the loom for the change, although the loom may be stopped by hand in the usual way without engaging the pin clutch.

All the operations for the change are controlled by two cams, mounted on this cam shaft. One of these cams, placed at the magazine side, controls the three operations of lifting the box front, ejecting the old shuttle and inserting the new one, whilst the second cam, mounted alongside the pin clutch at the driving end of the loom, is responsible for restarting the loom. The cam at the magazine side (fig. 23) first raises the shuttle-box front by means of suitable

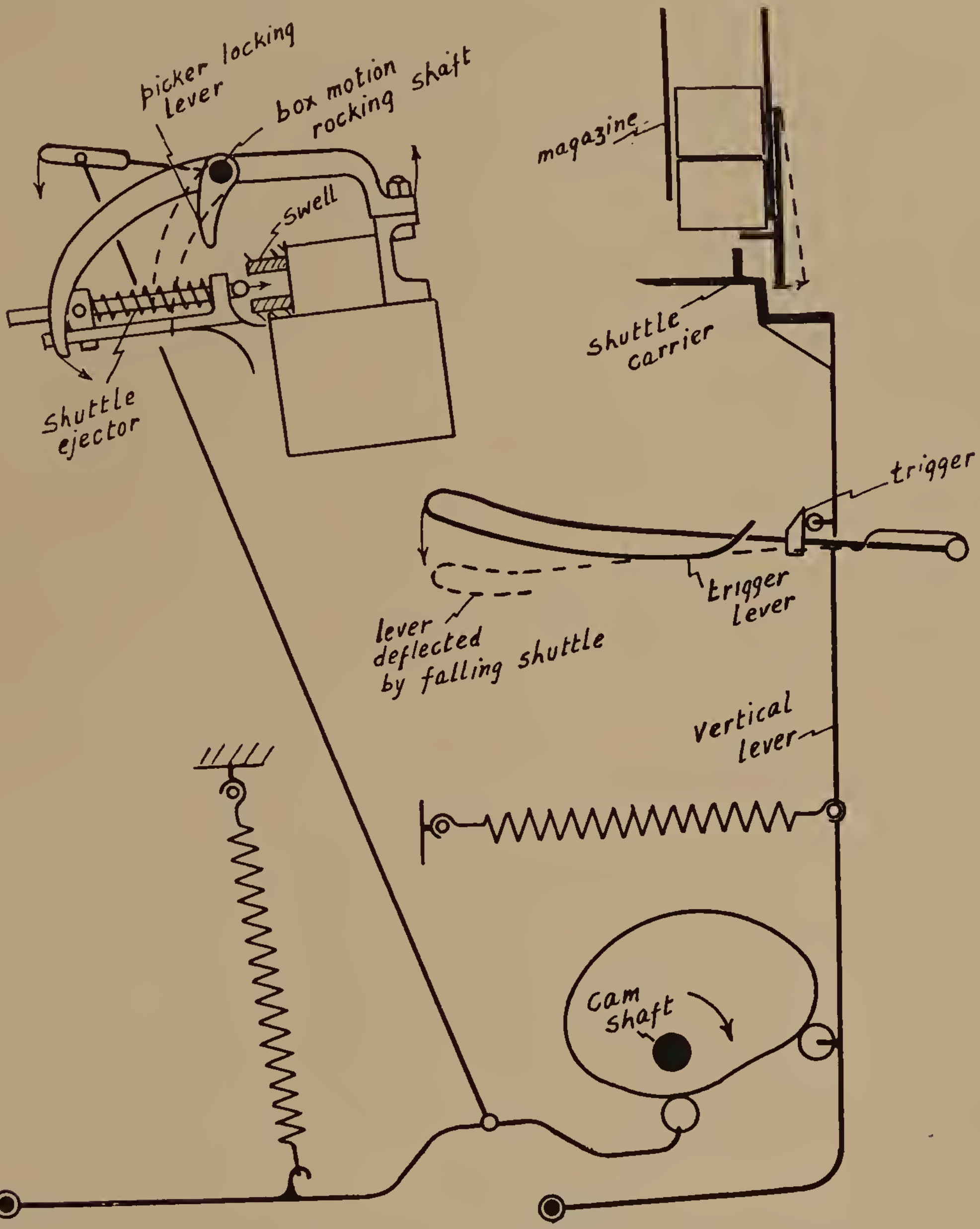


FIG. 23.—URQUHART LINDSAY LOOM—SHUTTLE-CHANGING MECHANISM.

levers and connecting rods. Secondly, the operation of raising the box front also throws out the empty shuttle by means of an ejector, working in a slide attached to the slay below the shuttle box. Thirdly, the cam has meantime carried forward a vertical lever, to which is fixed a shuttle-carrier shelf. This carrier is brought forward until it is immediately under the magazine, where it releases two spring catches and allows one full shuttle to drop from the magazine on to the carrier shelf. The shuttle carrier is now kept in this position by means of a trigger lever until the empty shuttle has been ejected. The empty shuttle falls on the trigger lever, releasing the shuttle carrier, which is moved towards the slay by a spring, and places the full shuttle in the empty box. The carrier is withdrawn by the cam, the box front closed by a spring, and when these operations are completed the loom is ready for restarting.

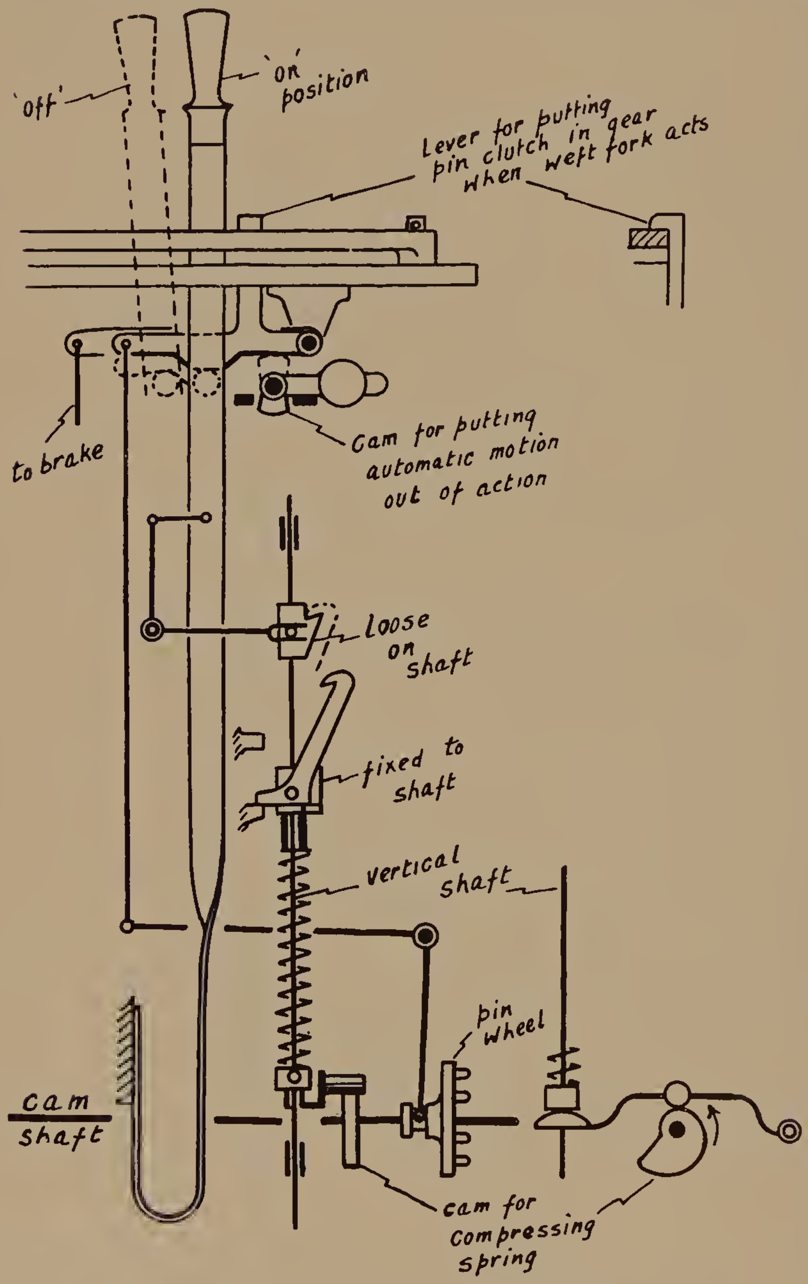

'off'
'on' position
Lever for putting pin clutch in gear when weft fork acts
to brake
Cam for putting automatic motion out of action
loose on shaft
fixed to shaft
vertical shaft
pin wheel
cam shaft
cam for compressing spring

Fig. 24.—Urquhart Lindsay Loom—Starting Gear.

The second cam, which is situated at the driving side, has meantime been compressing a strong spring on a vertical shaft placed near the spring set-off handle (see fig. 24). The lifting of the shaft engages a catch, fixed to the shaft, with another which is connected, as shown, by levers to the set-off handle. The cam is constructed with a quick return contour, and when this comes into operation, after a new shuttle has been inserted, the spring is released, carrying down the vertical shaft, which pulls on the handle through a bell-crank lever. At the same time the pin clutch is withdrawn, stopping the cam shaft, the band brake is released, and the main clutch is closed, thus starting the loom.

A number of subsidiary motions and safety devices are fitted. A spring-buffer stop is fitted for the magazine side picker, since the ordinary martingale check strap cannot be used at that end of the slay. A picker-locking lever, fitted at the back of the shuttle box, ensures that the picker forms no obstruction to the ejection of the empty shuttle and the insertion of the full one. The cam shaft is fitted with a small band brake to keep this shaft set to its proper timing. This shaft also, acting through a small eccentric, lifts the uptake motion catch out of its working position. A locking catch also comes into operation on the uptake ratchet, and prevents any movement of the uptake during the shuttle change. A locking catch is fitted on the front of the slay to prevent any changing of the shuttles while the slay is in its forward position, this catch engaging, at each forward stroke of the slay, with the trigger lever which controls the shuttle-carrier movement. Finally, a small lever, conveniently placed, enables the weaver to put the automatic motion out of action at once should it be desired to run the loom in the usual way.

Important advantages claimed for this automatic motion are that it can be applied without materially affecting the standard design of the loom, whilst the mechanism is simpler than that of similar motions. No special shuttles are needed, or alteration of the form of cop, and as the shuttles are not in continuous operation, they do not become overheated, and consequently their life is increased. If the automatic motion should temporarily go out of order, the loom may at once be used as an ordinary loom.

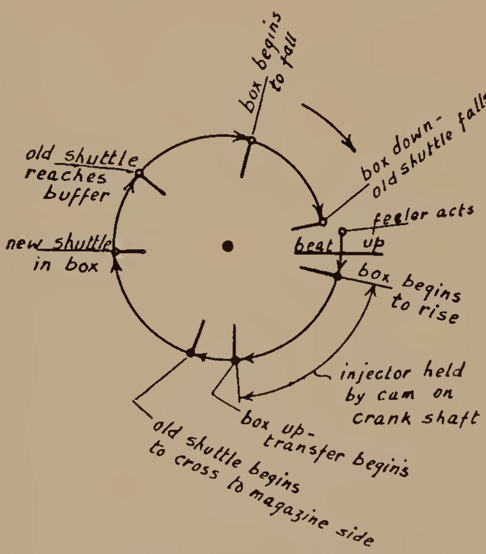

box begins to fall
box down-old shuttle falls
old shuttle reaches buffer
feelor acts
new shuttle in box
beat up
box begins to rise
injector held by cam on crank shaft
box up-transfer begins
old shuttle begins to cross to magazine side

Fig. 25.—Hansen Loom—Timing Diagram.

The Hansen Loom.—In this loom, which is a Danish invention, the shuttle change is effected with the loom running at full speed, yet, as will be seen from the timing diagram given in fig. 25, there is a reasonably long time for the insertion of the new shuttle and also for getting the old shuttle clear. The mechanism is simple and works well, but so far it has not been used on a very extended scale. The magazine is a stationary one, the bottom shuttle being kept in position by two spring clips at the front, which yield to allow the shuttle to be pushed out from behind by the injector (see fig. 26). When the latter is withdrawn after transfer, the remaining shuttles drop by gravity, leaving the bottom one in position for the next change. The new shuttle is pushed into the shuttle box from the back, and to enable this to be done, the empty box is lifted to the level of the bottom shuttle in the magazine while the old shuttle is yet at the feeler end of the slay. The shuttle-box back and swell are fixed, and it is only a skeleton box, with an open back, that is lifted to receive the new shuttle. Whilst the new shuttle is being inserted in this way in the lifted shuttle box, the old shuttle reaches the magazine side and passes underneath the lifted shuttle box, being guided to the end of its movement by a narrow guide ledge fixed to the shuttle box. At the end of its movement the shuttle tip is caught by a buffer, supported by a check strap, and the shuttle is then stopped in much the usual way. The shuttle, being now supported by the narrow ledge along one edge and by the swell, is lowered with the shuttle box, and when it gets below the swell it tilts sideways and drops into a chute down which it slides gently to the empty shuttle receptacle.

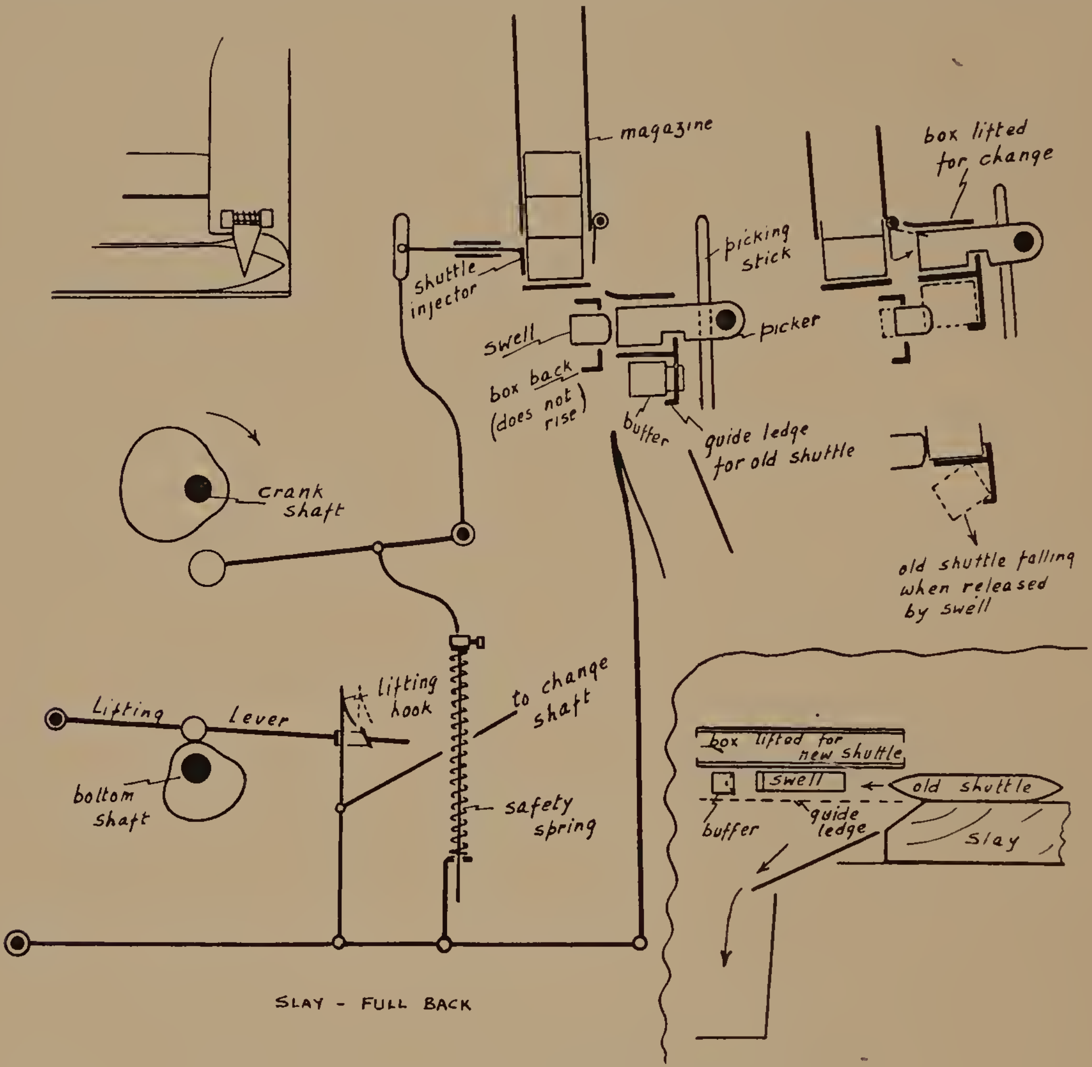


FIG. 26.—HANSEN LOOM—SHUTTLE-CHANGING MOTION.

The lifting of the shuttle box is effected through the simple lever arrangement shown, when a lifting hook, which is normally clear of a lifting lever, is moved into contact with the latter through the action of the feeler. The lifting lever is operated by a cam on the bottom shaft, and this lever rises and falls every two picks. The same cam and lever which lift the box are utilised to move the shuttle injector, through the injector link and the bell-crank lever to which the injector is attached. The movement of the shuttle injector is also controlled by the cam on the crank shaft. The injector must not begin to move the shuttle until the box has been lifted to receive it, and, since the injector would start moving at the same time as the box, it is necessary to prevent the movement of the injector until the proper time. This is done by the full part of the cam on the crank shaft being kept in contact with the bowl at the end of the lower arm of the injector bell-crank lever until the box is up. During the rising of the box the safety spring is compressed, the spring also yielding to prevent damage if any obstruction occurs during the insertion of the shuttle in the box. The cam on the crank shaft is also used to draw the injector clear of the shuttle box before the latter begins to descend, so as to prevent any danger of the injector being caught by the falling box.

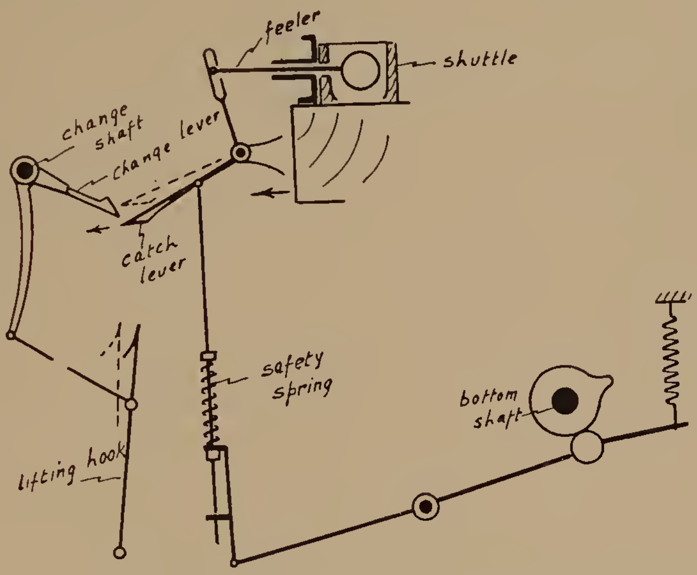


Fig. 27.—Hansen Loom—Weft Feeler Motion.

The feeler motion is illustrated in fig. 27. The feeler itself is attached to a catch lever, which is acted on by a cam on the bottom shaft in such a way that the feeler is brought into contact with the pirn in the shuttle every time the latter is at the feeler side. Normally, the complete entry of the feeler is prevented by the yarn on the pirn, the catch lever being prevented from lifting to the full extent of the throw of the cam, this being permitted by the compression of the safety spring. The end of the catch lever thus passes under the end of the change lever fixed to the change shaft as the slay beats up, until, when the weft is almost exhausted, the feeler allows the catch lever to engage with the change lever and the latter is depressed, which has the effect of moving the lifting hook at the other end of the loom into position for engaging with the lifting lever which operates the shuttle change.

As compared with the shuttle-changing looms which stop for the change, this loom has a much simpler change mechanism, since it gets rid of all the difficulties attendant on stopping the loom accurately and restarting it in a satisfactory manner. Theoretically it saves time through not stopping, but that is a minor point, as the loss of time due to stopping for the shuttle change is very small. On the other hand, the time available for making the change is much reduced as compared with the time available with the stopping loom, and there is, in consequence, more danger of damage to shuttles and to the loom itself if the change is not satisfactorily performed.

CHAPTER V

COP-CHANGING ATTACHMENTS

With the object of enabling manufacturers to secure the benefits of lower weaving wages by means of automatic weaving, without having to incur so heavy capital charges as are needed for changing over from ordinary type looms to new automatic ones like the Northrop or the Stafford, several attachments have been introduced for replenishing the weft automatically. Although they were intended originally to be fitted on old looms, it has generally been found desirable to use these attachments on new looms of the ordinary type, since an existing loom must be in very good condition and nearly new to make it worth while to fit the motion.

In addition to the weft replenisher, a warp stop motion is essential, and it is highly desirable that an automatic let-off should be fitted, although the latter is often omitted and the weaver is expected to adjust the tension through the ordinary lever and weight let-off. When the cost of the weft replenisher, the warp stop motion, and the automatic let-off is added to the cost of the ordinary loom, the total is not far short of the price of a fully automatic loom, and there is little doubt that the latter is the more satisfactory. A point that weighs with some manufacturers in favour of the attachment is that it can be fitted to any make of loom, and the use of the attachment enables the manufacturer to continue to use looms to which he may be accustomed.

The majority of cop-changing attachments work on the same general principle as the Northrop, the cop transfer being done by means of a transfer hammer operated from the slay movement. Naturally, simplicity and cheapness have been aimed at in the designing of these motions, aims that are good so long as efficiency of working is retained. The magazine, for example, is generally stationary and inclined, and the bobbins descend this by gravity when the bottom one is removed by the transfer hammer. This arrangement is simple and works satisfactorily, and, if desired, it permits of the use of a cone overpick motion. On the other hand, the thread cutter and shuttle positioner, whilst often simpler than the Northrop, is not always so satisfactory in its working, and the same applies to the feeler motion, which is often of the type used by the Northrop before the side-sweep type was introduced.

The Whittaker Attachment.—The arrangement of the magazine is shown in fig. 28, and it will be seen that the bobbin in position for insertion is kept in place by a spring plate, which yields under the pressure of the hammer on the bobbin, but closes in again as soon as the bobbin has passed. The shuttle used is a Northrop type shuttle, and the method of holding the bobbin in the shuttle, and of threading up, is the same as in the Northrop.

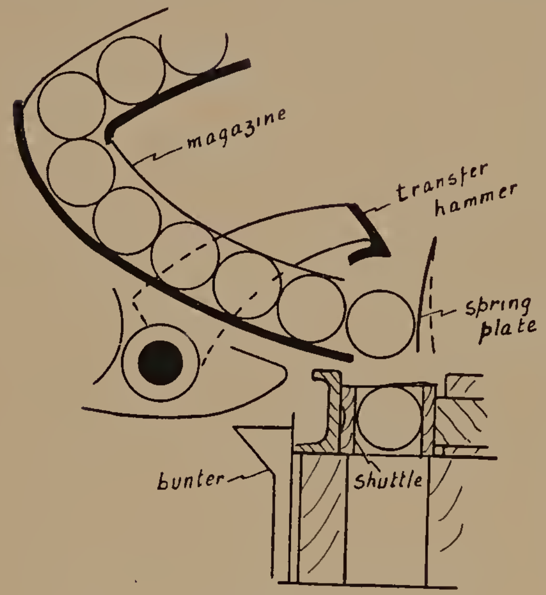


Fig. 28.—Whittaker Attachment—Magazine.

The movement of the transfer hammer is shown in figs. 29 and 30, the former showing the parts just as movement of the bunter lever is beginning, and the latter the beginning of the downward movement of the hammer. The movement of the bunter lever is due to movement given to the change shaft A by the weft-fork hammer, either directly when a feeler is used, or through the medium of the weft-fork lever when change is effected through the weft fork. The hammer and its shaft are free to move, the hammer being normally kept in the up position by a coiled spring. The downward movement is effected by a driving pin which passes through the bunter lever, and which is brought in contact with a projection on the hammer when the bunter lever is moved into the changing position. This pin is also seen in the plan view (fig. 31), and here it will be seen that the pin can be withdrawn from acting on the

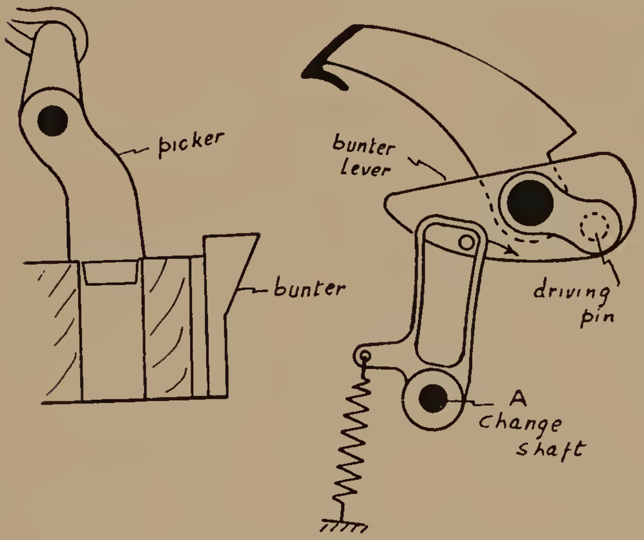


Fig. 29.—Whittaker Attachment—Transfer Hammer.

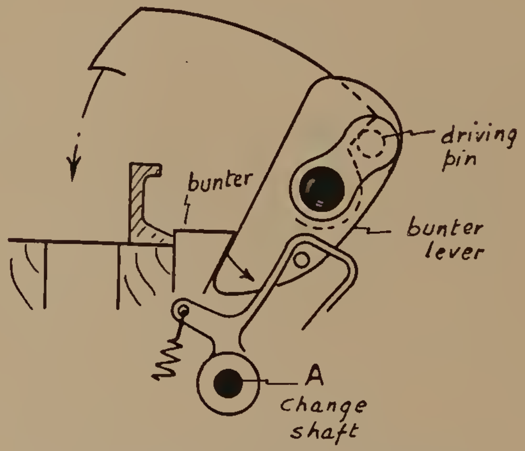


Fig. 30.—Whittaker Attachment—Bunter and Bunter Lever.

hammer. This occurs if the stop on the cutter is moved back to the dotted position, allowing the spring on the driving pin to withdraw the latter from action. The cutter can be moved back by hand if it is desired to put the change mechanism out of action; it also happens automatically if, when a change is needed, the shuttle fails to get far enough home in the box, so that the shuttle fouls the end of the open cutter blade and pushes the cutter back. When out of action in this way, the driving pin has to be pushed back into its normal position, by hand, before change can take place. The cutter acts also as a positioner, for, if the shuttle is not quite home when a change is needed, the shuttle tip is acted on by the edges of the recess in the fixed cutter blade and is pushed home into the box far enough to allow of the change. If the shuttle tip is so far from its correct position that it fouls the end of the moving cutter blade, the latter prevents a change, as just described. If the shuttle fails to get home properly when the cutter is closed—that is, when no change is needed—the shuttle tip pushes back the cutter, but usually not quite far enough to allow the spring to withdraw the driving pin.

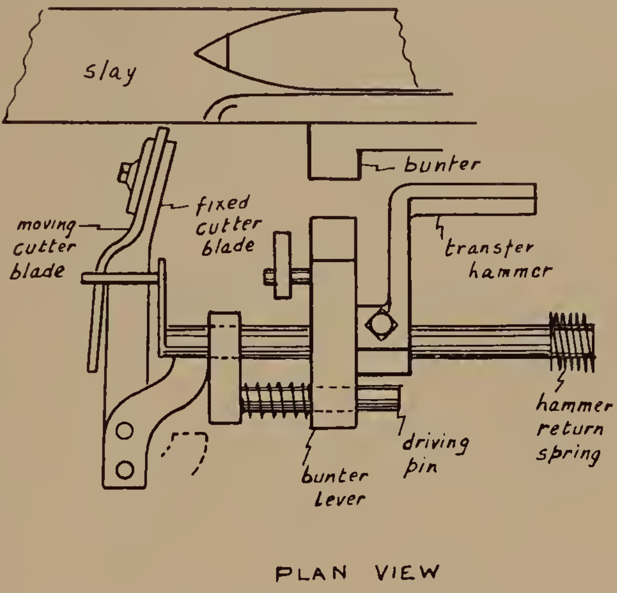


Fig. 31.—Whittaker Attachment—Plan of Thread Cutter.

The arrangements for cutting and holding the old weft are seen in plan view in fig. 31 and also in fig. 32. As the change shaft A moves for the change, a pin on a lever fixed to A strikes a projection on the movable cutter blade and opens the cutter, as shown. Another pin, fixed to the hammer fulcrum-shaft, projects over the top of the cutter blade, and during the first part of the downward movement of the hammer this pin closes the cutter blade, thus cutting the thread, the end next the cloth being retained in the closed cutter until the latter is opened for the next change. A second cutter is provided beside the temple, and this cutter, which opens and closes every pick by the movement of the slay, cuts both old and new wefts close to the selvedge.

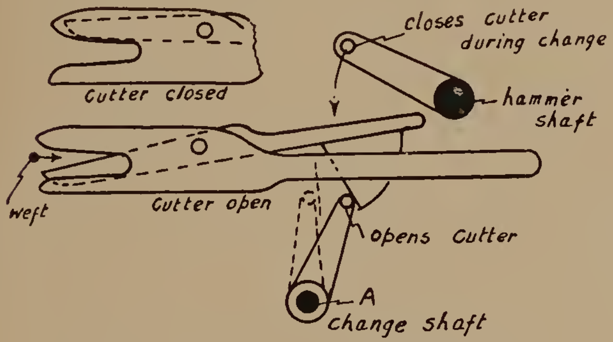


Fig. 32.—Whittaker Attachment—Thread Cutter.

The Whittaker motion can be, and very frequently is, applied to an overpick loom, and, to enable the cop to be inserted from the top of the shuttle, the picker spindle has to be set back and the picker at the magazine side specially shaped, whilst, if for any reason the picker fails to be drawn clear of the magazine, the latter yields to the pressure when the slay beats up.

When change is effected through a feeler, the end of a feeler rod passes through a hole in the weft-fork hammer lever and is carried to and fro with the latter. Normally, the position of the rod is such that it misses a lever fixed to the change shaft A at the end of the loom opposite to the magazine end. But through the action of the feeler, when the weft is nearly exhausted, this rod end is moved nearer and nearer to the lever on the change shaft, until finally the two engage and the forward movement of the weft-fork lever turns the change shaft and so shifts the bunter lever.

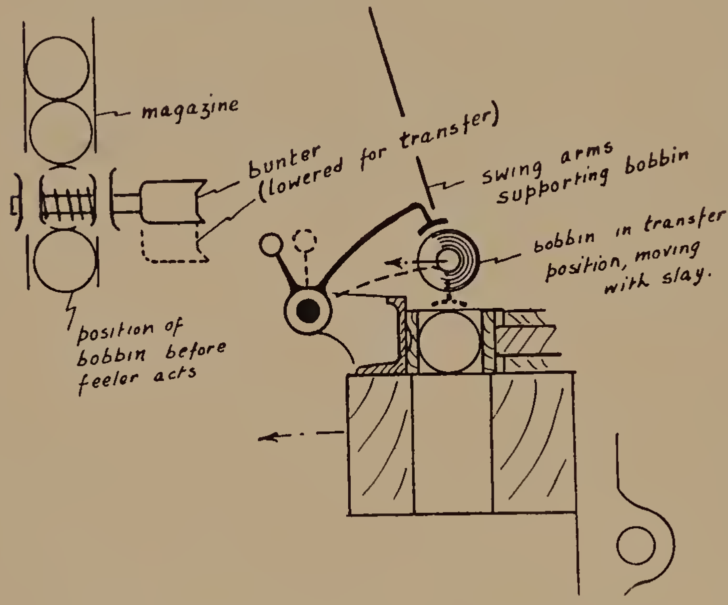

magazine
bunter (lowered for transfer)
swing arms supporting bobbin
bobbin in transfer position, moving with slay.
position of bobbin before feeler acts

Fig. 33.—Terry Attachment—Diagram showing Action.

The short time available for changing the cop is often considered to be one of the weak points of cop changers working on the Northrop system, since the change must be done whilst the slay is practically stationary at the beating-up position. The time available is actually longer than is frequently supposed, since there is very little movement of the slay for a considerable angular movement of the crank on either side of the front centre. But even allowing for this, the time is comparatively short, and motions have been designed to lengthen this time available for the change, with a correspondingly easier change. One of these is the Terry automatic motion (fig. 33). The bottom cop from the stationary magazine is taken by a carrier, which is set in action by the change mechanism, and moved towards the advancing slay. After the cop is in position over the shuttle, which occurs when the slay is about half-way through its forward movement, the cop and its carrier are moved forward by the slay, the cop remaining directly over the spent one in the shuttle and the time for the change being increased, since the change may take place at any time after the cop is in position. The hammer lever is mounted on, and pivots about, a pin fixed to the slay, and a bunter fixed to the lower part of the magazine gives movement to the hammer when the bunter has been lowered into the operative position through the action of the feeler or the weft fork. The times available for the change in Northrop and Terry systems respectively are approximately as shown in fig. 34, and it will be evident that whilst a considerable gain in time is effected by this motion, it is not quite so great as might at first be supposed.

Another motion which is designed with the same object of increasing the time for the change is that of Messrs Henry Baer & Co., Zurich. The feature of this motion is that the shuttle is turned on its edge and works in that position instead of on the flat, the weft leaving the shuttle through an eye in the top of the shuttle instead of the side (see fig. 35). The change-hammer head works horizontally instead of vertically, pushing the new cop into the shuttle through a gap in the box front, and the old one out through a gap in the back of the box. Here, again, the cop is in a position suitable for change for a considerable period, and the change is correspondingly easier. It is very doubtful, however, whether the shuttle works so satisfactorily on its edge as on its flat, and the depth of shed must certainly be greater for a given size of cop than with the usual shuttle, and this must result in some extra strain on the warp threads.

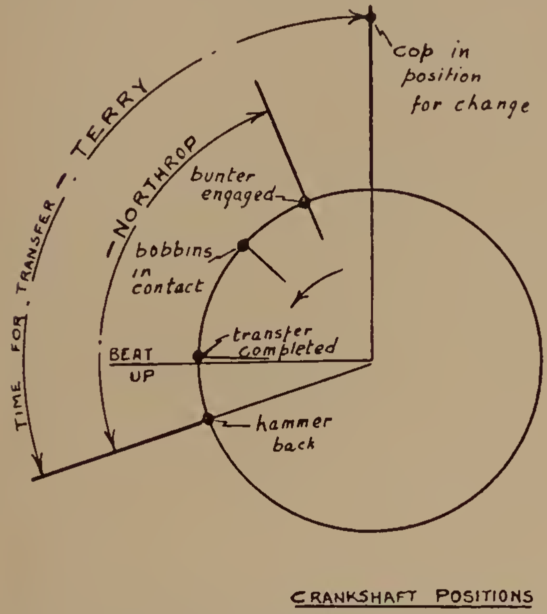


FIG. 34.—TIMING DIAGRAM FOR NORTHROP AND TERRY TRANSFER.

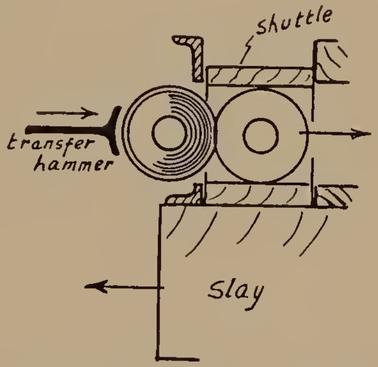


FIG. 35.—BAER COP-CHANGING SYSTEM.

CHAPTER VI

MULTIPLE-BOX AUTOMATIC LOOMS—THE NORTHROP SYSTEM

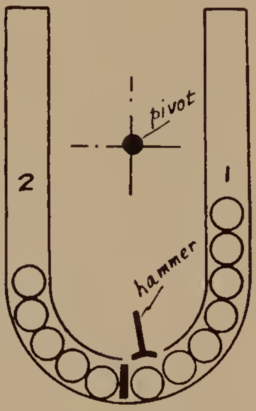
At first sight it might appear that the complication of adding automatic mechanism to a multiple-colour loom would be too great to permit of its being done satisfactorily, and that there is not the same need for it as in the single-shuttle loom, due to the lower speed and to the greater number of shuttles in use. But, although there may be four shuttles in use, with the result that any one shuttle requires replenishment at comparatively long intervals, yet, on the average, there are practically as many weft replenishments in a given time as in a single-shuttle loom, and the weaver requires to be much more vigilant, for an eye has to be kept on the weft supply in all of the four shuttles. It will thus be evident that there is practically as good an argument, if not a better one, for the application of automatic mechanism to multiple-box looms as to single-box looms, provided that the weft-replenishing mechanism is satisfactory in character and the cloth not too complicated in structure. There are, naturally, great difficulties in the way of applying an automatic weft-replenishing mechanism to "pick at will" looms, with multiple boxes at both ends of the slay, and for cloths requiring looms of this type it will probably be long before automatic weaving is available. But the great majority of multiple-box looms have the moving boxes at one side only, and, moreover, much of the cloth woven on such looms is simple in structure—often plain cloth—and for these conditions automatic looms have been introduced by several firms. It will also be readily understood that cop changing on such looms is easier than shuttle changing, and although, as already described, the Hattersley shuttle changer is made in a two-shuttle type for weft mixing, its use is limited to one kind and colour of weft.

Although looms have been built having six boxes at one side, for six different colours of weft, the majority of multiple-box automatic looms have either two or four boxes at the changing side. In the case of the two-box looms the box motion may be of a simple continuous acting type, the box change taking place regularly every two picks, conditions that are necessary in weaving fabrics such as crêpes, where two different wefts are used, picked two and two, or in weaving many high-class, self-coloured fabrics, where it is necessary to mix the weft from two shuttles to prevent stripes developing, due to slight differences in shade in the various pirns used. For pattern work, whether with a two- or a four-box motion, a suitable box motion must, of course, be provided, capable of being operated either from a pattern chain or from the dobby or Jacquard.

The arrangement of the automatic-replenishing mechanism for the two-shuttle loom may be the same whether the box motion is a simple weft-mixing type or a more complicated pattern type, but some firms take advantage of the rather simpler conditions in the former loom to fit a correspondingly simpler automatic motion. Some of the looms, both four- and two-shuttle, use mechanical feelers and mechanical transmission of the various movements, whilst in others electric feelers and electrical transmission of certain of the movements are introduced. There is a good deal to be said in favour of each of these. On the whole, most manufacturers, in England at any rate, prefer mechanical motions which can readily be understood, and there is undoubtedly some difficulty, in a factory, in keeping electrical contacts and other electrical parts in good working condition. On the other hand, the electrical feeler is simple, and the use of electric transmission often reduces considerably the amount of mechanism needed to transmit a movement from one part of the loom to the other. If the rest of the mechanism works satisfactorily there is nothing to fear from the use of electric currents on the loom, but it must be admitted that the wholly mechanical motion, if satisfactory in its working, will very often be preferred.

Northrop multiple-box looms are made in considerable variety, the principal types being two-shuttle and four-shuttle looms. The former may either be of the check type, in which the drop boxes are worked from a pattern chain, or they may be of the rather simpler "crêpe" variety where the boxes change every other pick.

Northrop Two-shuttle "Check" Loom.—This loom, in common with other Northrop looms for more than one weft, is partly operated mechanically and partly electrically. In all of these looms the weft-changing mechanism is of the same mechanical type as is used on the ordinary single-shuttle loom, a transfer hammer being operated through the medium of a bunter and bunter lever to effect the change of pirn. Electrical means are employed, however, to detect the need for a change and to set the changing parts in action.



Nº 1 Colour normally in position – magazine swivels for Nº 2 Colour

Fig. 36.—Northrop Two-colour Swivelling Magazine.

The magazine is of a two-compartment swivelling type (fig. 36), in which the bottom pirn in each compartment is held in position by a spring clip, which yields under the pressure of the changing hammer. The next pirn slips automatically into position by gravity, after the transfer hammer has returned. In the earlier looms of this type, the magazine was oscillated from the box motion, so that the correct colour of weft was always in position ready for transfer. In later models, however, the magazine is normally stationary, with the bottom pirn for No. 1 box in position, directly below the hammer, ready for the change, and swivelling of the magazine is only necessary when No. 2 colour has to be transferred, this movement of the magazine occurring just before the transfer takes place. In this way much unnecessary movement of the magazine is eliminated, cutting out, also, much vibration of the pirns.

The electric feeler is fitted at the magazine side and is generally a modification of the usual side-sweep feeler, the feeler blade, when it swings sideways, touching two contact points and completing an electric circuit between them. Electro-magnets then put the changing mechanism in action in a similar manner to that described in connection with the four-shuttle loom. The completion of the feeler circuit moves a control lever,, and by that movement registers the need for a full pirn of the same kind of weft as that which is nearly finished. The shuttle then returns to the drop-box side, and the next time it is picked across to the magazine side the transfer is effected. After the feeler has registered the need for a new pirn in one shuttle, the box motion may change and the weft may be changed in the other shuttle without effecting the registration which will effect the change in the original shuttle when next it is picked across to the magazine side.

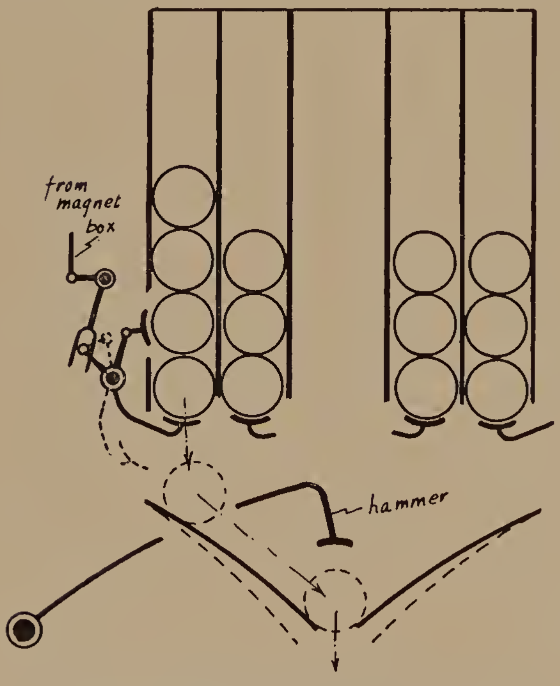


Fig. 37.—Northrop Four-shuttle Loom—Magazine.

Northrop Two-shuttle "Crêpe" Loom.—In this type the electrical feeler is placed at the drop-box side, a feeler being placed above the boxes to detect the need for change in the top shuttle when it rises into the inactive position. A similar feeler is placed below the boxes, and acts on the bottom shuttle when it is lowered out of action. The feelers are generally of a simple two-prong type, the prongs entering the shuttle and making contact with a metal sleeve on the pirn when the latter is bared of weft. The completion of the electrical circuit in this way is used to cause an electro-magnet to lift the change lever into contact with the weft-fork hammer, and also, if necessary, to swivel the magazine to bring the correct weft into the changing position. The action of the transfer parts must, of course, be delayed for two picks until the shuttle that needs new weft is ready for picking across to the magazine side. For crêpe and similar weaving, which needs two different kinds of weft, a swivelling magazine similar to that used on the check loom is necessary, but if the looms are used only for weft mixing, where only one kind of weft is used, the ordinary circular battery, as used on the single-shuttle loom, is all that is needed.

Northrop Four-shuttle Loom.—In this loom, as in the other Northrop box looms, electrical means are used for detecting the need for a change, for getting the correct colour of pirn ready for transfer, and for starting the action of the changing parts, whilst the actual transfer is effected by the usual mechanical methods. The drop-box motion is a combination of the Swiss hook and griffe motion and a floating lever operated by means of two eccentrics. In addition, a hand control enables the weaver readily to raise or lower any box into the working position when finding the pick, or for any other purpose. The pattern

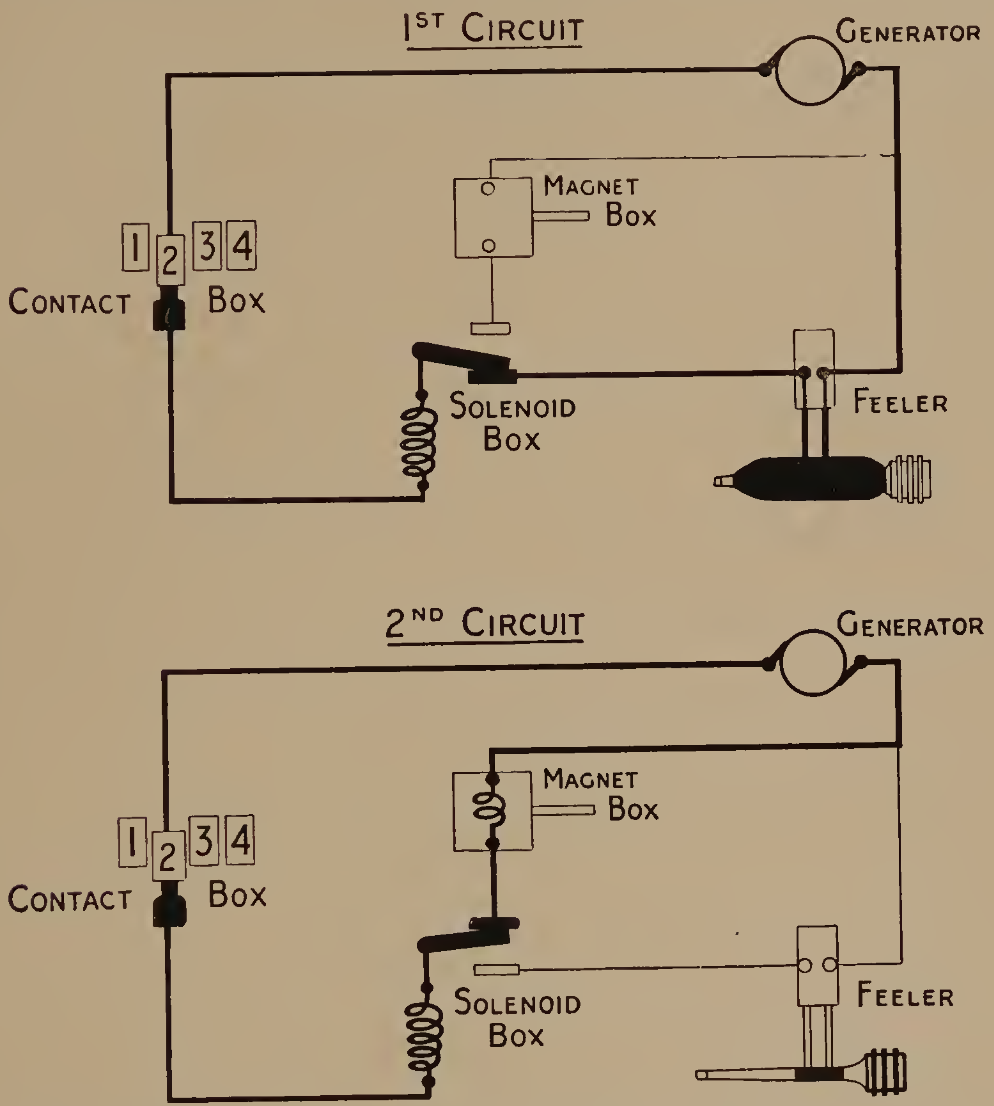


Fig. 38.—Northrop Four-shuttle Loom—Diagram of Electrical Circuits.

chain operates on the "one card, one box" principle, each card bringing its own box in line with the slay irrespective of the previous position of the boxes.

The magazine is a stationary one, with four vertical grooves for the different coloured bobbins, the bottom bobbin of each colour being kept in position by a trap, which is operated from the magnet box on the back of the magazine when transfer is required (see fig. 37). The feeler is of the side-sweep type, making electrical contact as in the two-shuttle check loom, and this feeler is placed at the magazine side. The electrical control is illustrated by the theoretical diagram in fig. 38. A contact box, situated at the drop-box side, contains four numbered contacts which are controlled by the four needles operated by the box-motion pattern chain. When one of these needles is pressed back by a card it puts in circuit the solenoid or electric magnet which controls the weft supply for that particular box. There are four such circuits, one for each box, and that for box No. 2 is shown in the illustration. Normally, this circuit is broken at the feeler, but when the weft is almost withdrawn from the pirn, the metal sleeve on the pirn or the side movement of the side-sweep feeler blade completes the circuit. The current passes through an electro-magnet in the solenoid box, and this causes a contact arm to change position, as shown in the lower diagram, the change breaking the first circuit and completing a second This results in the electrical energy now causing a magnet in the magnet bo to move a solenoid plunger and depress a trigger. The movement of the contact arm puts the feeler out of circuit for this particular shuttle, and at the same time registers the need for a new supply of weft. This is shown in the lower diagram. The magnet box is now in circuit, and this controls the lowering of the pirn from the correct compartment of the magazine and th setting in action of the change mechanism. These actions are delayed until the box-motion pattern chain has presented its card, which occurs when the slay is about full back, and the shuttle is crossing from the magazine to the drop-box side. After the need for a fresh pirn has been registered by the feeler, it is immaterial whether the nearly empty shuttle remains active, or is rendered inoperative through the boxes changing. Changes of other colours of weft may also be made without affecting the registration originally made the change being effected on the first passage of the shuttle to the magazine side after the shuttle is again brought into use. When the drop boxes have to change between the registration of the need for a change and the actual transfer, the box-motion pattern card changes the contacts in the contact box, thus breaking the circuit to the magnet box and preventing the change. When the circuit is again completed, however, as the original shuttle is brought into use, the change takes place as though there had been no interruption.

As soon as the second circuit is completed through the magnet box as shown in fig. 38, and also in fig. 39, one electro-magnet, as already stated, depresses a trigger, as shown at (*b*), fig. 39. At the same time a second electro-magnet, at the drop-box side of the loom, tries to lift the change lever, which operates the shuttle positioner and bunter lever through the weft-fork hammer head in the usual way. It is prevented from doing so by the position of the hammer head, but when the proper time arrives, it brings the two into contact. The trigger seen in fig. 39 is rocked to and fro by a rocking shaft, which carries four of these triggers, one for each compartment of the magazine. When the trigger is depressed as at (*b*), if it continues in this position it engages with the catch shown and the rocking movement is given also to the catch lever, which is loose on the rocking shaft. The movement of the catch lever is used, through suitable lever connections, indicated in the diagram, to drop the bottom bobbin to the changing position. When the support is removed from the bottom bobbin a grip presses on the next bobbin and prevents more than one bobbin from falling. The bottom support is moved into position again after a bobbin has fallen, and the grip is released, lowering the bobbins on to the support.

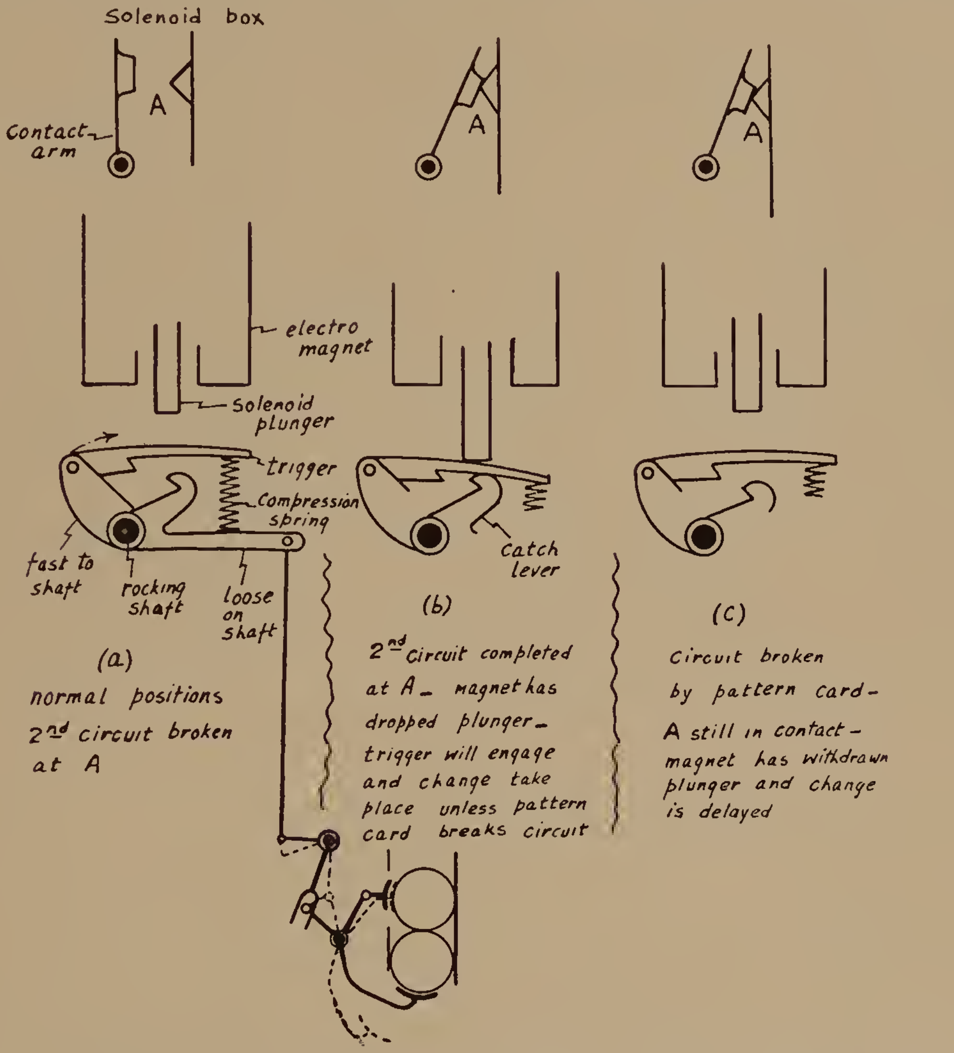

Solenoid box
A
Contact arm
A
A
electro magnet
Solenoid plunger
trigger
Compression spring
fast to shaft
rocking shaft
loose on shaft
Catch lever
(a)
normal positions
2nd circuit broken at A
(b)
2nd circuit completed at A — magnet has dropped plunger — trigger will engage and change take place unless pattern card breaks circuit
(c)
Circuit broken by pattern card — A still in contact — magnet has withdrawn plunger and change is delayed

Fig. 39.—Northrop Four-shuttle Loom—Diagram of Action of Magnet Box.

This is the normal action for a change, but if the presentation of the box-motion card breaks the circuit which has been completed by the contact arm at A, the solenoid plunger is lifted again as at (*c*), so that the bobbin is not lowered, while at the same time the other magnet ceases to exert its lifting force on the change lever. Transfer is therefore postponed, but A remains in contact, and when the pattern chain again completes this circuit the operation is continued at once.

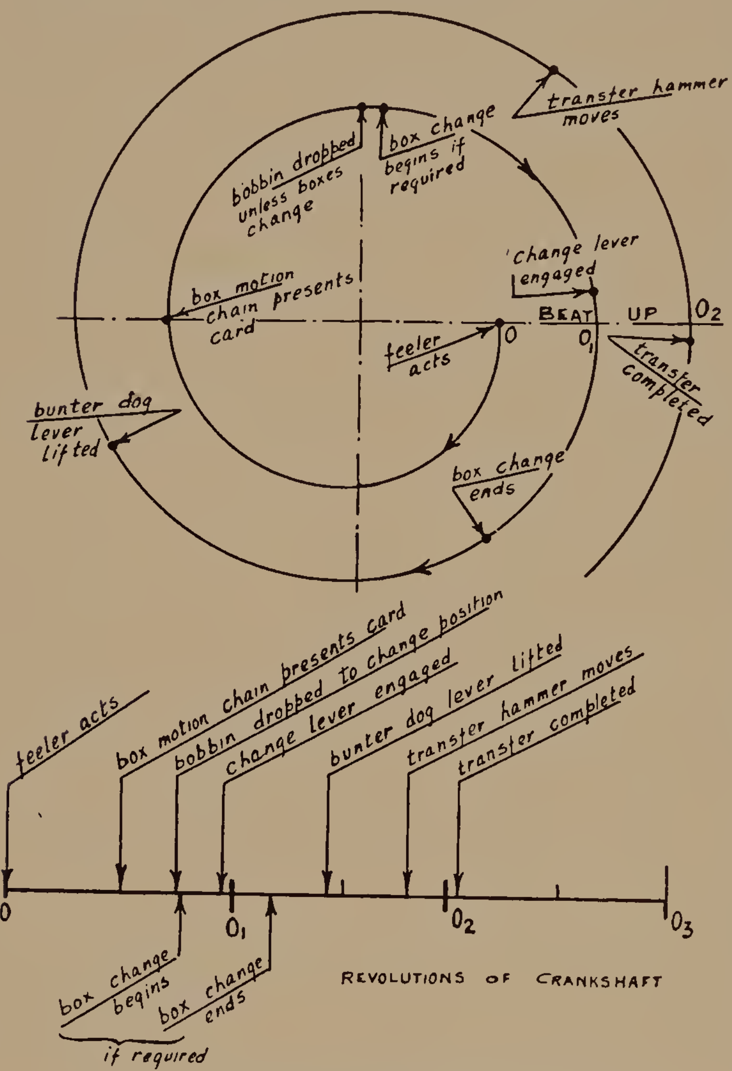


Fig. 40.—Northrop Four-shuttle Loom—Timing Diagram.

The approximate timing for the various movements is given in fig. 40, and it will be realised that ample time is available for the different movements, which is much in excess of that in other four-colour looms, as can be seen, for example, from the corresponding diagram for the Ruti loom (fig. 43). This is accounted for by the fact that in looms like the Ruti the movement of the boxes has to be *completed* before the bobbin can be put in position and the bunter lever lifted. In the Northrop system these actions can be begun as soon as the box-motion pattern chain has been presented, and that takes place much earlier than the beginning of the box movement, not to speak of the end of the movement.

CHAPTER VII

RUTI FOUR-SHUTTLE LOOM

The Ruti two- and four-shuttle looms are fitted with weft-replenishing motions which are entirely mechanical in their action. The looms are fitted with positive drop-box motions operated by cranks or eccentrics, so arranged that similar links on the pattern chain always bring the same box to the working position. The looms are fitted with cone underpicks, and their construction, in general, is of a high class.

The four-shuttle loom has a double circular magazine (fig. 41), the inner and outer rings being capable of independent movement about their common centre. One-half of each ring is devoted to the pirns of each colour, and when a change of pirn is required, the bottom pirn of the correct colour is brought into the changing position by the magazine being swivelled, clockwise or counter-clockwise, according to which movement is needed to bring the required colour below the changing hammer. In normal working there is a clear space below the hammer, and the magazine has to be moved into position before each change, returning immediately afterwards to the normal position. The feeler is at the magazine side, which is at the opposite end from the drop boxes, and after the feeler decides that a change is necessary, the shuttle returns to the drop-box side. As the shuttle returns to the magazine side the correct magazine is swivelled into position, the bunter lever is lifted, and the thread cutter set in motion, so that all is ready for the change when the shuttle gets home in the box. The transfer itself is effected in a similar way to that in the Northrop loom, and as soon as the transfer hammer returns, after the change, the magazine swings back to its central position.

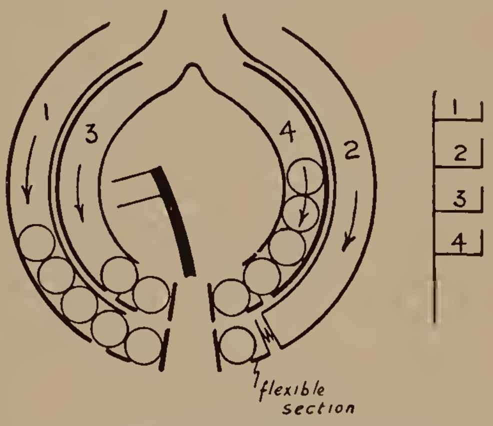


Fig. 41.—Ruti Four-shuttle Loom—Magazine.

The movement of the magazines is effected through two links, one end of each being attached to its respective magazine whilst the other end is lifted and lowered in unison with the drop boxes (fig. 41). Movement is given to the links, and to the magazines, through driving bowls which engage with driving grooves on the links. These driving bowls are moved by a driving hook, which, when a change is required, is dropped to engage with another hook which is reciprocated by a cam on the bottom shaft. The driving bowls are connected by levers, as shown, so that they always move in opposite directions and only one of the two is active, the other being made inoperative by the groove flanges being broken as indicated. Thus, in the position shown, the left-hand bowl will drive the top link to the left, moving the inner magazine clockwise, whilst the other bowl moves to the right clear of the groove. (Actually the two grooves are on opposite sides of the links and behind each other, but they are shown side by side for greater clearness.)

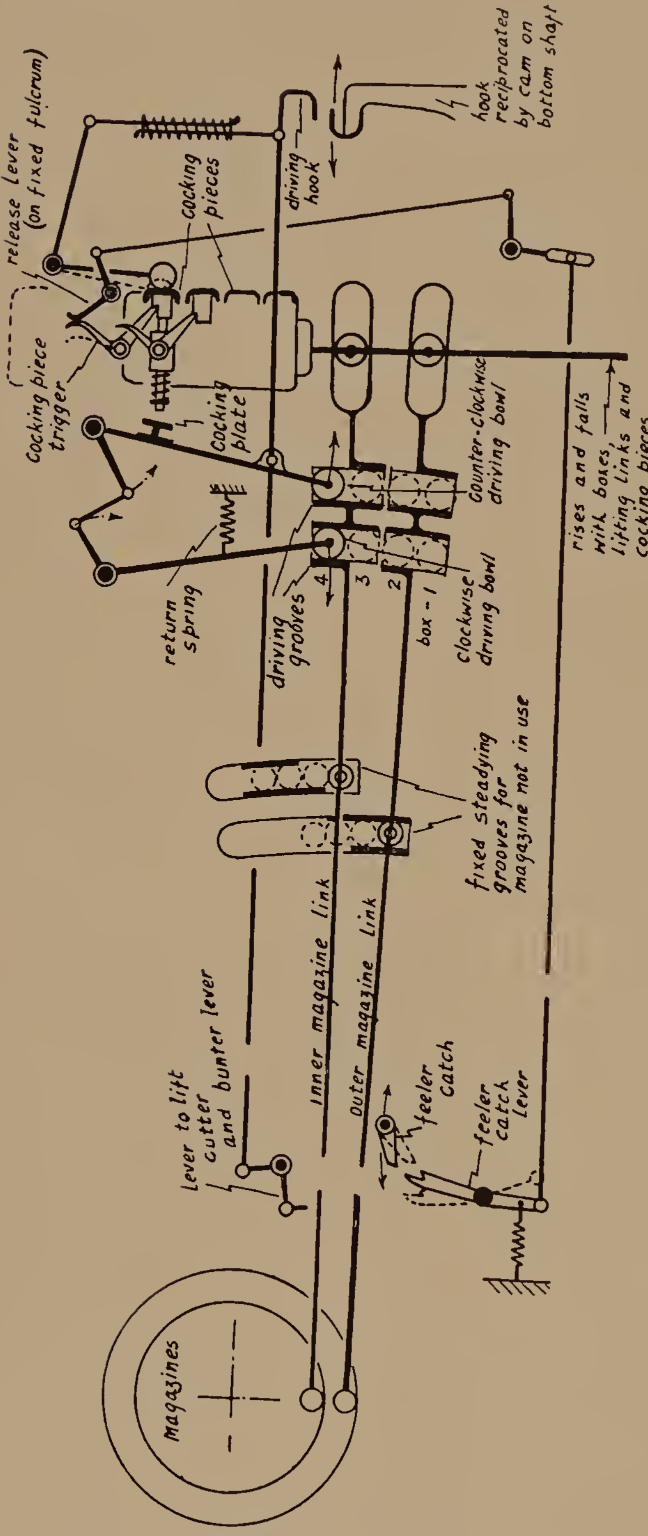

release lever (on fixed fulcrum)
cocking pieces
driving hook
hook reciprocated by cam on bottom shaft
cocking piece trigger
cocking plate
counter-clockwise driving bowl
rises and falls with boxes, lifting links and cocking pieces
return spring
driving grooves
4
3
2
box - 1
clockwise driving bowl
fixed steadying grooves for magazine not in use
inner magazine link
outer magazine link
lever to lift cutter and bunter lever
feeler catch
feeler catch lever
magazines

FIG. 42.—RUTI FOUR-SHUTTLE LOOM—MECHANISM FOR MOVING MAGAZINES.

Accidental movement of the magazines is further prevented by fixed steadying grooves, which lock the magazine not in use. Thus, in the figure, the outer magazine is prevented from movement by a bowl on its driving link being confined between the two flanges of its steadying groove.

The driving hook is normally kept in the disengaged position shown, by suspending it from levers which are kept in place by a bowl which presses against one of four spring-loaded cocking pieces, each of which is normally kept cocked by a trigger. These four cocking pieces are fixed to the vertical link which is controlled by the box movement, and which lifts and lowers the magazine link ends, so that when the boxes change, a change is also made in the cocking piece which supports the driving hook. Each cocking-piece trigger, as it is lifted or lowered into the operative position by the box movement, comes in contact with a release lever which is connected by levers to the feeler-catch lever. When the feeler allows the catch to engage with its lever, the release lever acts on the cocking-piece trigger and releases the cocking piece, which moves back under the action of the spring far enough to allow the driving hook to engage. The cocking piece is automatically recocked by a cocking plate, which is mounted on the driving lever, the plate coming in contact with the end of the cocking-piece spindle whilst the driving hook is moving the magazine. Release of the cocking piece takes place near the beat-up, with the shuttle at the magazine

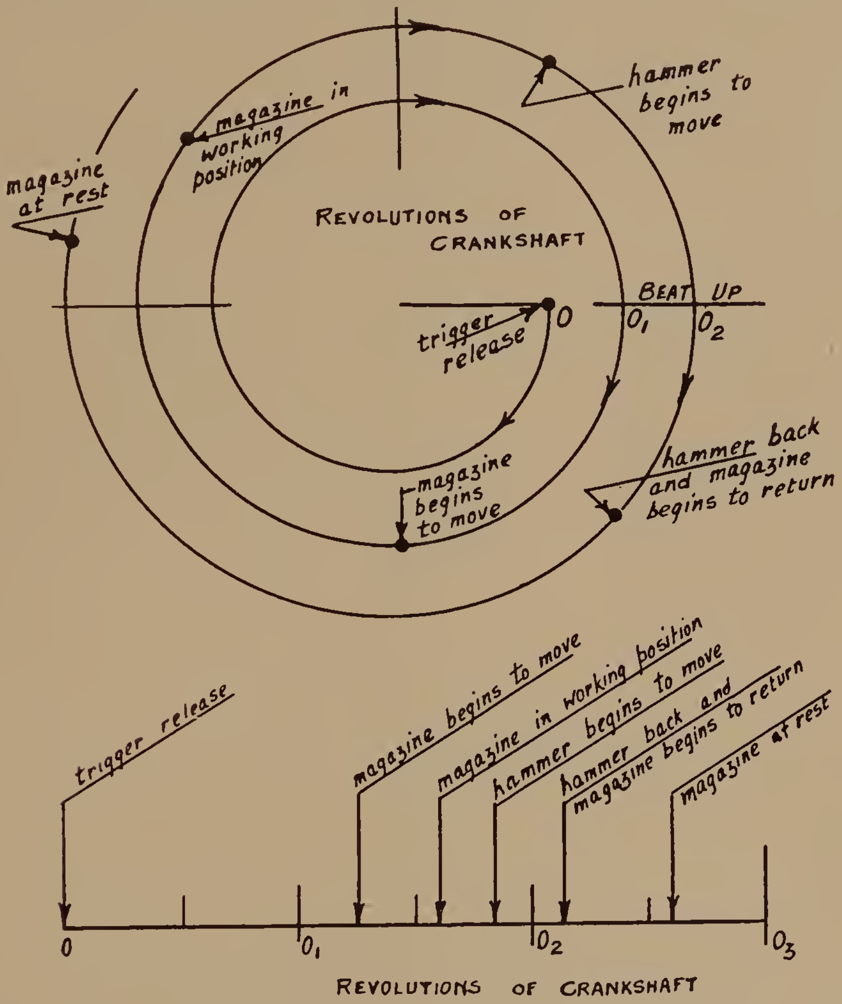

hammer begins to move
magazine in working position
magazine at rest
REVOLUTIONS OF CRANKSHAFT
BEAT UP
trigger release
0
0_1
0_2
magazine begins to move
hammer back and magazine begins to return
trigger release
magazine begins to move
magazine in working position
hammer begins to move
hammer back and magazine begins to return
magazine at rest
0
0_1
0_2
0_3
REVOLUTIONS OF CRANKSHAFT

FIG. 43.—RUTI FOUR-SHUTTLE LOOM—TIMING DIAGRAM.

side, but engagement of the driving hook does not take place until the crank shaft has made more than another complete revolution (see timing diagram, fig. 43), this being effected by working the lower hook from a cam on the bottom shaft. During this time the shuttle returns to the drop-box side, and if the box motion then changes, the transfer must be postponed until the original shuttle again comes into use. The cocking piece remains in the released position, so that whenever the original shuttle again comes into use its pirn is changed as soon as it has been picked across from the drop box to the magazine side. Normally, of course, release of the cocking piece is followed, two picks later, by transfer of the pirn, and it will be seen by reference to the timing diagram that reasonable time is available for all the movements.

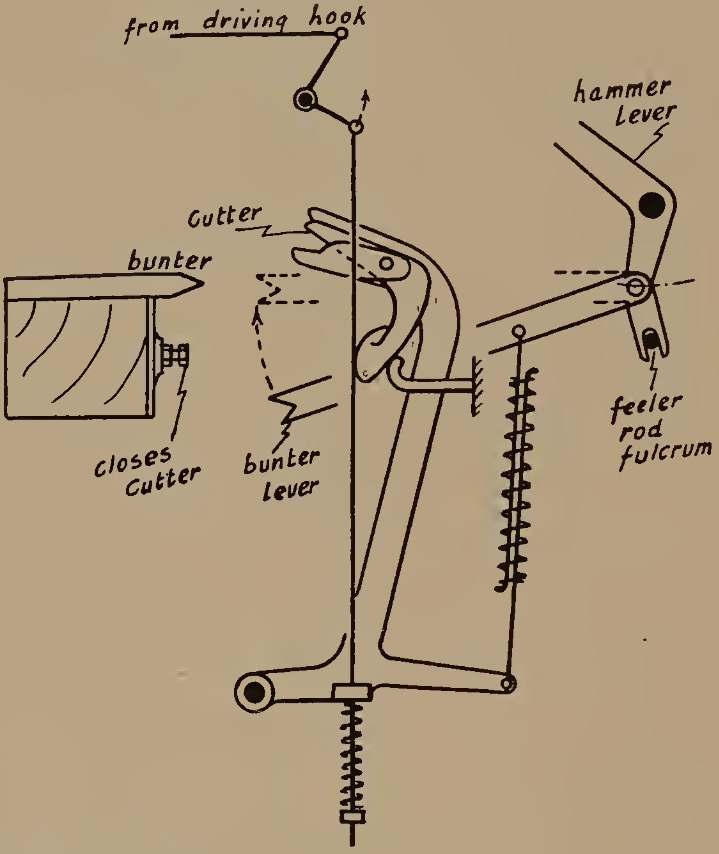
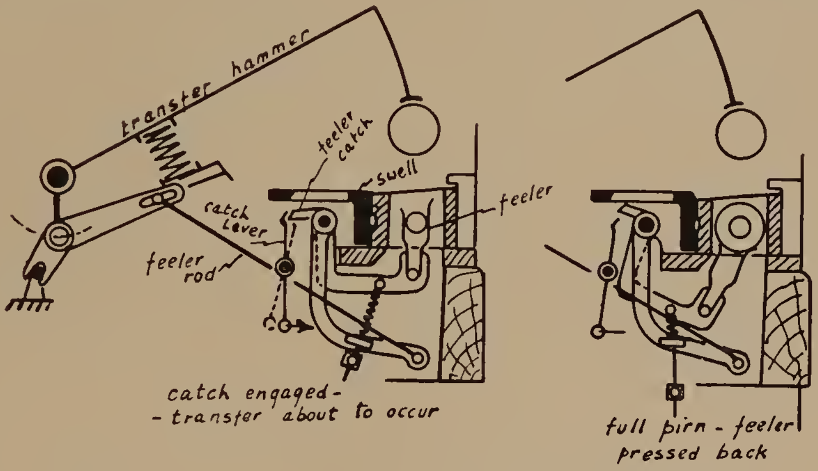


FIG. 44.—RUTI FOUR-SHUTTLE LOOM—THREAD CUTTER AND SHUTTLE POSITIONER.

The transfer hammer is operated in the usual way by means of a bunter on the slay, the bunter lever being lifted into contact with the bunter to make the change. Reference to fig. 42 will show that when the driving hooks are engaged, a bell-crank lever is operated and lifts the bunter lever and also the shuttle positioner and thread cutter. These parts are shown in outline in fig. 43, which shows the simple lever connections used to move these two parts. It will be seen that, as the open cutter is swung forward, it lifts the bunter lever.

If the cutter fouls the shuttle, owing to the latter not being properly home in the box, the safety springs yield, the bunter lever is not lifted, and the change does not take place. Normally, the thread cutter moves forward until a projection on the slay meets the tail of the movable cutter jaw, and closes the cutter to sever the thread, whilst the bunter lever is lifted against a stop and meets the bunter near the beat-up. On the return of the cutter, the jaws are opened by the tail on the movable jaw meeting a projection on the breast beam.

The feeler is in the form of a calliper, which feels at the diameter of the pirn every time the slay beats up, with the shuttle at the magazine side. The feeler jaw should be set so that it can pass over the pirn with one or two coils of weft left on it, and when this occurs, the feeler catch engages with the catch lever and the cocking piece is released. The action of the feeler is illustrated in figs. 45, 46, and 47, the first figure showing the feeler passing over the shank of the pirn and the catch engaged. The action of the feeler on a full or partly full pirn is also illustrated, the feeler spring yielding to allow of the feeler being pressed back by the yarn on the pirn. During transfer the feeler must, of course, be removed from the path of the ejected pirn, and this is shown in fig. 46, the movement of the transfer hammer being utilised to pull the feeler clear. Similarly, when the slay beats up with the shuttle at the drop-box end, the feeler must be thrown out of action, as otherwise it would release the cocking piece at that time. The feeler can only act when the swell, which is at the front of the box, has been pushed out by the entering shuttle. At other times a lip on the swell engages with the feeler catch and prevents the feeler from moving. This is shown in fig. 46, from which it will be seen that the swell, which is of metal, forms the whole of the shuttle-box front. Fig. 47 shows how the feeler is drawn away as the slay goes back, so that a clear path is left for the picking stick during picking.

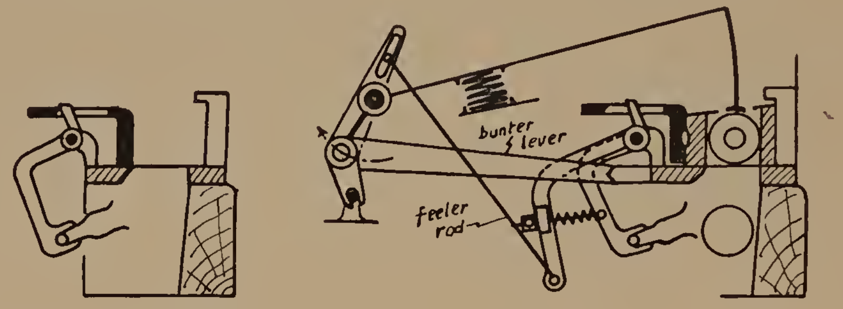


catch engaged - - transfer about to occur

full pirn - feeler pressed back

FIG. 45.—RUTI FOUR-SHUTTLE LOOM—WEFT FEELER.

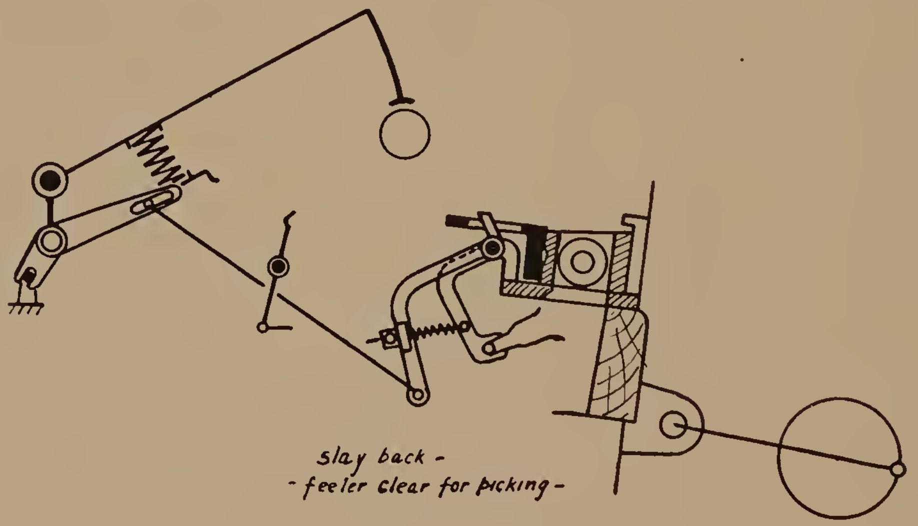
This type of feeler requires careful setting and good construction of the parts throughout for satisfactory working. Adjustment is provided for setting the distance between the feeler jaws, and for setting the feeler in relation to the slay. When well adjusted it gives good results, ensuring satisfactory changing with a very small percentage of waste left on the pirns. The upward pressure of the feeler tends to lift the shuttle and to prevent more than a limited amount of such upward movement; a small projecting flange is formed on the top of the box back. When properly adjusted, the feeler should act correctly whether the shuttle rests on the bottom of the box or is lifted against this flange.



beat up with shuttle at
drop box end - feeler catch
engaging with lip on swell

transfer of pirn -
feeler drawn back
by bunter lever and feeler rod

FIG. 46.—RUTI FOUR-SHUTTLE LOOM—WEFT FEELER.



slay back -
- feeler clear for picking -

FIG. 47.—RUTI FOUR-SHUTTLE LOOM—WEFT FEELER.

The return of the various parts to their normal positions, after a change, is effected by spring action. The magazines are weighted to swing to their normal position, and this is helped by a return spring acting on the driving-bowl levers. The weft cutter and the bunter lever are returned by their own weights, and a spiral spring, which is put in compression by the transfer hammer as it descends, is used to lift the hammer after the pirns have been changed.

It will be seen that the jaw of the thread cutter is relied on to hold the end of the cut piece of weft between the selvedge and the cutter until the temple cutter acts and cuts the old and the new wefts close to the selvedge. This temple cutter is normally inactive and is thrust forward, immediately after the transfer, to sever the old and new wefts before the former has had an opportunity of being drawn into the cloth.

The cocking pieces and triggers occupy rather an exposed position at the end of the loom, and the triggers are somewhat liable to be pressed back accidentally, so releasing the cocking pieces. Nothing of a dangerous nature happens, however, if this occurs, but a transfer of pirns takes place, unnecessarily, as soon as the box, whose cocking piece has been released, comes into work.

CHAPTER VIII

THE CROMPTON & KNOWLES FOUR-SHUTTLE LOOM

MESSRS CROMPTON & KNOWLES specialise in automatic looms for two or more shuttles. For this work they use a cop-changing system similar to the Northrop, so far as the insertion of the new and the ejection of the old cop is concerned, but the working of the feeler and automatic motion is quite distinct from that used on the Northrop check looms. Two-, four-, and six-shuttle looms are made, and the method of operation is the same in all, although naturally there are slight differences according to the number of shuttles and magazine cells used. The magazine used is a stationary one, with the pirns or bobbins of each colour in separate compartments or cells, from one of which the bottom pirn, when required, is allowed to fall down to the transferring position below the head of the transfer hammer, ready for the latter to transfer it to the shuttle. The feeler is at the magazine side, and the whole of the operations are mechanically controlled. After the feeler has indicated the need for a change, with the shuttle at the magazine side, the shuttle is picked across to the drop-box side. The pirn meanwhile is partly released, but it is not dropped right down to the changing position until the shuttle leaves the drop-box side, at which time, also, the transfer or bunter-dog lever is raised into line with the bunter on the front of the slay. If the boxes change when the nearly exhausted shuttle reaches the drop-box side, the pirn that has been partly released for transfer remains in this partly released position until the shuttle for which it has been prepared again comes into action.

Each set of pirns is supported by a cradle, as shown diagrammatically in fig. 48, which shows the bottom pirn of the left-hand cell lowered into the cradle and ready for release, so that it may fall on to the give-ways which support the pirn at its head and tip until transfer occurs. Each cradle is capable of being rocked or rolled through about 90 degrees by the action of a cam slot at the lower end of a slide when the latter is lifted, the cradle being returned to its original position when the slide is lowered. These parts can also be seen in fig. 49 and in the general view (fig. 50). The cam slot engages with a pin on the cradle, and the rising of the slide turns the cradle from the position shown for Nos. 2, 3, and 4 cells (fig. 47) to that shown for No. 1, this movement of the cradle allowing the pirns to drop from the normal position, so that the bottom pirn is in the cradle. The downward movement of the slide rocks the cradle back to its normal position, with the result that the top part of the cradle is first inserted between the bottom pirn and the next, and then the bottom part of the cradle releases the bottom pirn, which falls on to the giveways. The upward movement of the slide and the first movement of the cradle occur as the shuttle, which is ready for a new pirn, is going from the magazine side to the drop-box side, whilst the second movement, which finally releases the pirn, takes place as the shuttle is travelling back again to the magazine side. Each slide has two projections, the upper for lifting, the lower

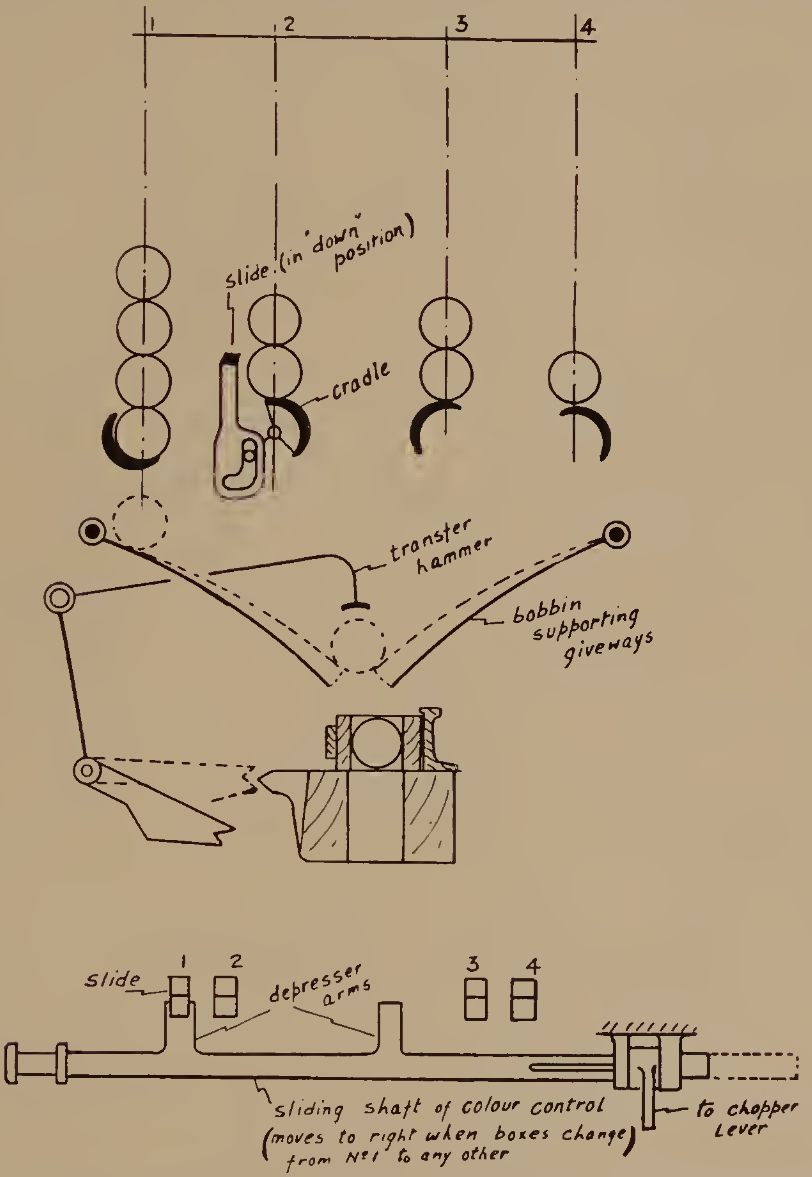

1
2
3
4
slide (in "down" position)
cradle
transfer hammer
bobbin supporting giveways
slide
1
2
depresser arms
3
4
sliding shaft of colour control
(moves to right when boxes change from No 1 to any other)
to chopper lever

Fig. 48.—Crompton & Knowles Four-shuttle Loom—Magazine.

for depressing it, the lifting and lowering being done by a depressor arm, which is swung first upwards to lift a slide and then down to lower it, these actions taking place when the feeler allows the feeler pin to remain below the chopper lever as seen at the bottom of fig. 49. This chopper lever normally moves up and down about its left-hand end, getting its motion from a cam on the bottom

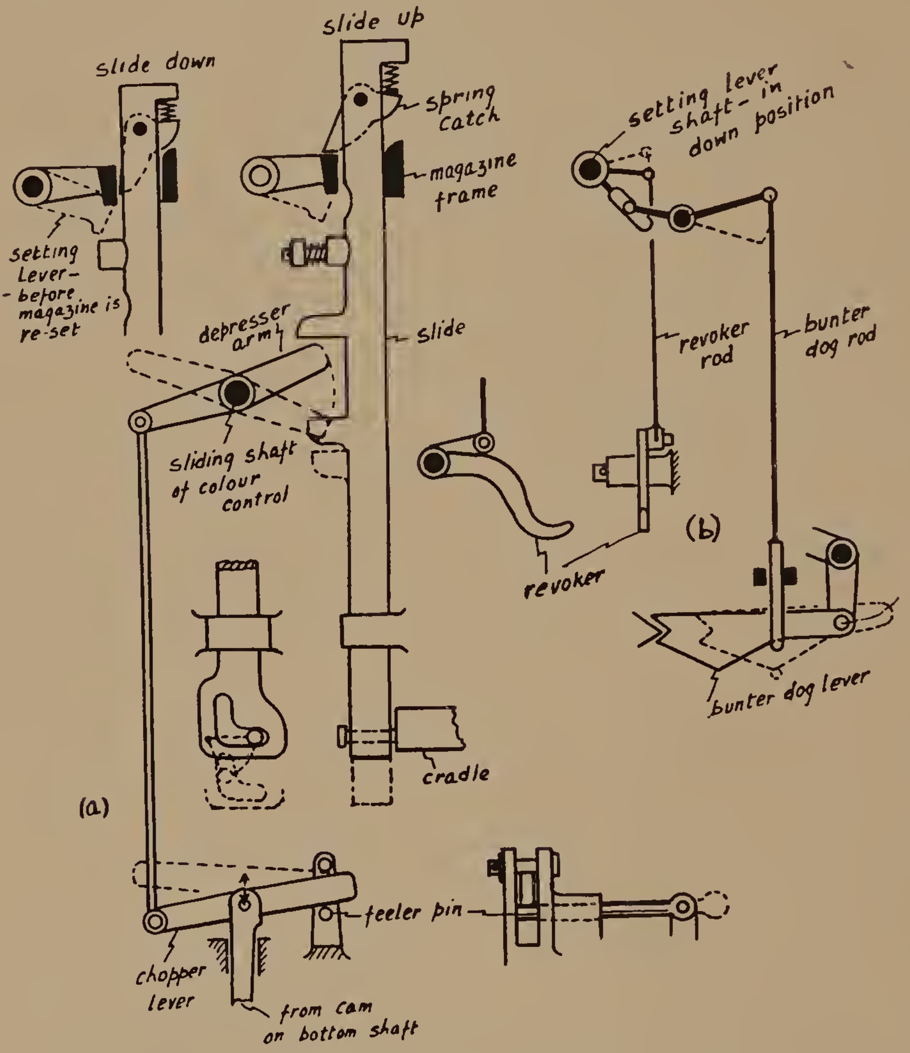


FIG. 49.—CROMPTON & KNOWLES FOUR-SHUTTLE LOOM—ACTION OF MAGAZINE.

shaft. The right-hand end normally swings up and down idly in a slot, the feeler pin being withdrawn from under the chopper by the action of the feeler so long as there is weft on the pirn. When the feeler allows the feeler pin to remain across the path of the chopper, the fulcrum is transferred to the feeler pin and the left-hand end of the chopper operates the magazine. Only one of the four slides is acted on when the depressor arms, of which there are two, rise. These arms are arranged as shown in plan at the bottom of fig. 48, which shows one of the arms in position for engaging with the slide for No. 1 colour.

The depressor arms are so arranged on the sliding shaft of the colour control that, as the drop boxes change, the sliding shaft is moved to bring a depressor arm into position for engaging with the slide for the correct colour.

When a slide is lifted, a spring catch at its top is free to engage with the blade of a setting lever, and on the downward movement of the slide the catch turns this setting lever about its fulcrum shaft, until a projection at the back of the catch comes in contact with the magazine frame, which trips the catch off the lever plate so that in the down position of the slide the catch lies flush with the slide face. The turning movement thus given to the setting-lever shaft results, as shown detached at (*b*), fig. 49, in the lifting of the bunter-dog lever into position to meet the advancing bunter on the slay, and also in lowering the shuttle revoker or positioner into place just in front of the shuttle-box mouth, as seen in the sketch of the magazine in fig. 50. Normally, the bunter dog is then pushed back by the bunter, thus operating the transfer lever and completing the transfer. The bunter-dog rod, which lifts the dog, is prevented by stops from moving with the dog when the latter is moved back by the bunter; the under-surface of the dog is made with an incline which acts as a cam on the rod end, and, as the dog is pushed back, this cam action pulls the dog rod down. This lifts the setting lever to its normal position, lifts the revoker, and so resets the magazine. The dog itself falls down to its normal position when released by the bunter after beat-up. The lower end of the revoker should clear the shuttle tip by about $\frac{3}{16}$ inch when the shuttle is properly boxed. If, through the shuttle failing to get home properly in the box, the shuttle tip strikes the revoker, the latter is forced upwards, which has the effect of turning the setting-lever shaft, lowering the bunter dog so that transfer does not take place, and resetting the magazine. The feeler must act again on the bobbin, and the operations must be repeated, before transfer can take place. When the revoker is up, in its normal position, the bobbin-supporting giveways are

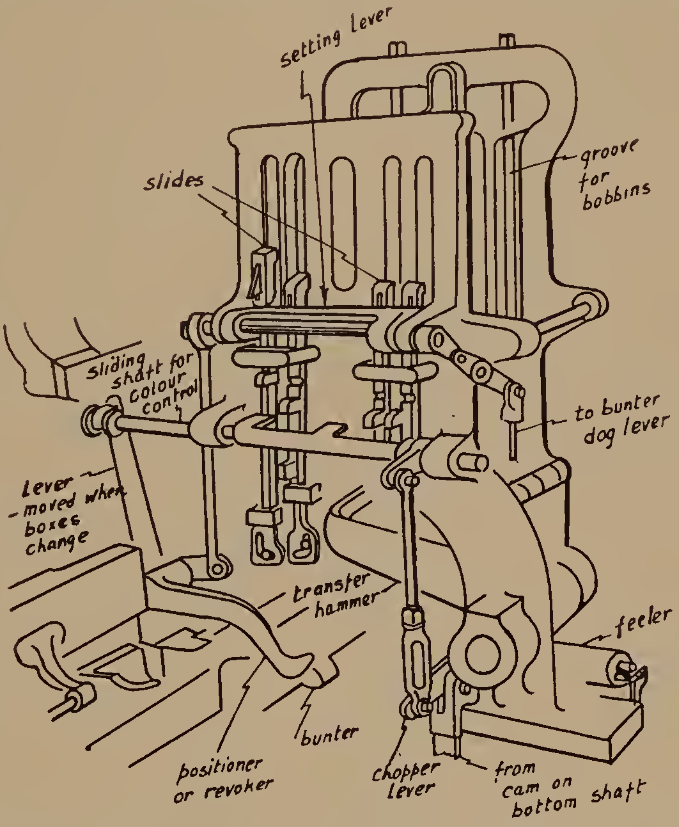


FIG. 50.—CROMPTON & KNOWLES FOUR-SHUTTLE LOOM—GENERAL VIEW OF MAGAZINE.

open enough to allow a bobbin to fall through, but when the revoker is moved down, a stud on the revoker arm causes the opening between the giveways to be reduced, so that they support the bobbin when it is released, until the transfer lever forces it through the giveways and into the shuttle. When the revoker returns to its up position, either normally after transfer or through having been struck by a shuttle not properly boxed, the bobbin-head release opens again. This is a safety precaution, and makes it possible for only one bobbin to be in the transferring position at any time. If a bobbin has been dropped into the transferring position and the magazine revokes, the giveways open and the positioned bobbin drops out into the bobbin can. Indication has then to be repeated, but two bobbins in the giveways would result in a smash or the wrong colour on the next transfer. Since the face of the feeler enters the shuttle when the latter is at the magazine side, it is necessary to withdraw the feeler when transfer is about to take place. This is done by a stud on the lower arm of the transfer lever, this stud striking an arm on the feeler case and withdrawing the feeler when the transfer hammer is moving down to effect the transfer.

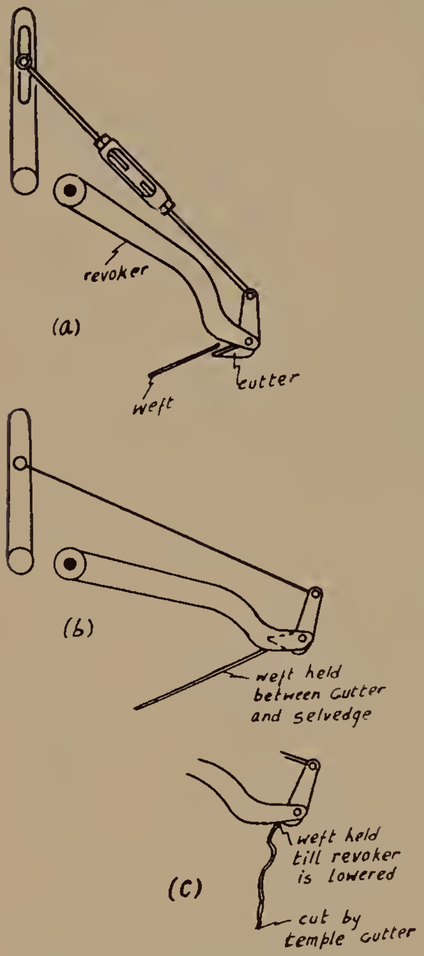

revoker
(a)
cutter
weft
(b)
weft held between cutter and selvedge
(c)
weft held till revoker is lowered
cut by temple cutter

Fig. 51.—Crompton & Knowles Four-shuttle Loom—Thread Cutter.

The motion as illustrated in fig. 50 is not provided with a cutter for the old weft, which is consequently rather liable to be drawn into the cloth if the falling of the old bobbin does not break the weft and draw the end clear of the shuttle eye. To reduce this tendency for the end to be drawn in, a cutter and holder can be fitted, and acts in conjunction with the revoker. A cutter blade and holder is fitted to the lower end of the revoker, and this blade is connected to a fixed arm so that when the revoker falls, before a transfer, the cutter opens to receive the thread (fig. 51 (*a*)). Just before the transfer the cutter starts to rise, and this closes the blade, cutting the weft on the side next the outgoing bobbin and holding the end towards the selvedge (fig. 51 (*b*)). A few picks later the temple cutter cuts this piece of weft, which then hangs down as shown in fig. 51 (*c*). When the cutter is lowered for the next transfer this piece is released and drops between the breast beam and the slay. The downward movement of the cutter starts some time before the shuttle gets across to the magazine side, and the piece of weft has time to fall clear.

The feeler is of the side-swing type and is illustrated in fig. 52. The serrated swing jaw, together with the fixed jaw, enters the shuttle when the latter is at the magazine side, and the jaws come in contact with the bobbin, as shown detached. The fixed jaw is set a little in advance of the swing jaw, the latter being adjustable on its pivot, which is an eccentric screw. Normally, the point of the fixed jaw readily penetrates the soft yarn on the bobbin and allows the serrated edge of the swing jaw to make contact with the yarn which prevents any side movement of the swing jaw, and both jaws are pushed back together by the bobbin. If, however, the yarn is almost exhausted, the serrated jaw does not make contact, or makes only very slight contact, with the yarn, and as the fixed jaw is pushed back by the bobbin, the swing jaw moves sideways on its pivot away from the fixed jaw. The swing jaw always tends to make this side swing when the feeler is pushed back by the bobbin, but normally the contact between the yarn and the serrated edge prevents it. The swing jaw is in the form of a bell-crank lever, one arm of which comes in contact with a push rod when the feeler is pushed back by the bobbin. This push rod goes to the rear of the feeler case and its end butts against a vertical arm, which is fixed to the shaft which operates the feeler pin or indicating plunger. This feeler pin, it will be remembered, is normally withdrawn from underneath the chopper lever, but remains under this chopper if a change is needed. A spiral spring, shown as the feeler spring, is always acting so as to push the feeler pin beneath the chopper, but if the push rod is moved back by the feeler, the push rod overcomes the force of the spring and withdraws the feeler pin in time to let the chopper descend. It will be noticed that the resistance of the feeler

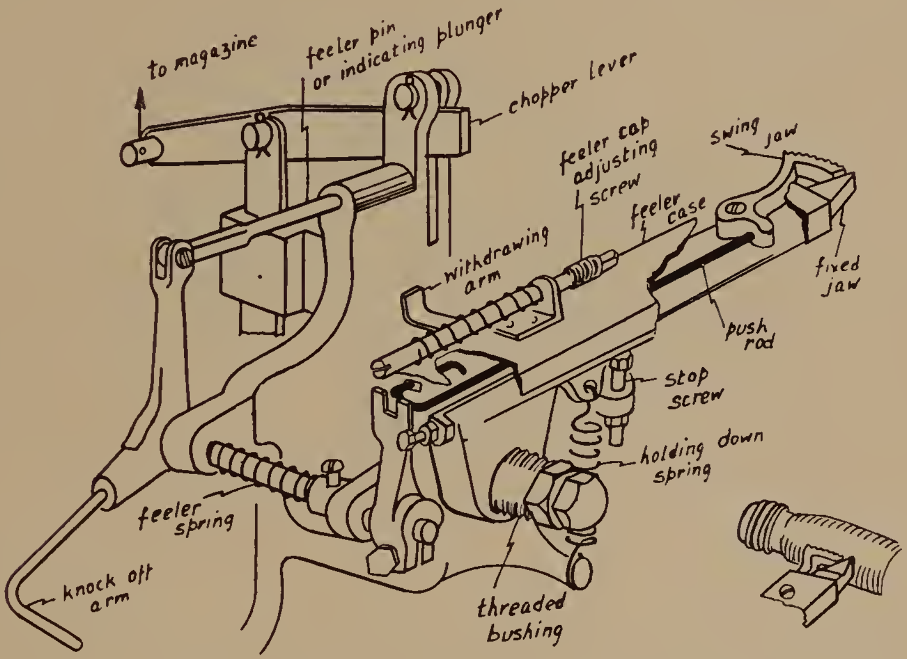


Fig. 52.—Crompton & Knowles Four-shuttle Loom—Weft Feeler.

spring, acting along the push rod as the feeler is pushed back, is tending to move the swing jaw away from the fixed jaw. When this side movement of the swing jaw takes place, the push rod and the feeler pin do not move when the feeler case is pushed back, and the chopper lever starts the magazine. The feeler case slides in a groove formed in the feeler bed, not shown in fig. 52 but clearly seen in fig. 53, which also shows the cap which is screwed to the bed. The feeler cap-adjusting screw, shown on the top of the feeler case in fig. 52, carries a spring which butts against a small bracket shown fixed to the feeler case, whilst the other end bears against the cap, which is not shown.

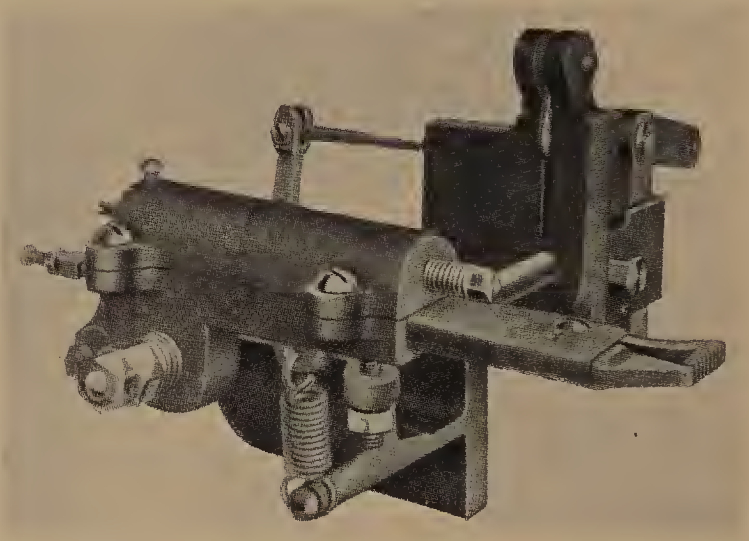


Fig. 53.—Crompton & Knowles Four-shuttle Loom—Weft Feeler.

This spring serves to return the feeler case after it has been pushed in by the bobbin. The feeler bed, carrying the case, is mounted on a threaded bushing, about which it can pivot, being normally held down against a stop screw by the holding-down spring. The threaded bushing permits of sideways adjustment of the feeler, whilst the spring allows the feeler to tilt upwards if any obstruction comes between the feeler and the shuttle box. When transfer of bobbins is taking place, the feeler has to be kept clear of the shuttle, and this is done by the withdrawing arm, shown projecting from the top of the feeler case. A stud, on the lower part of the transfer lever, strikes this as the transfer hammer is going down, and withdraws the feeler case from the shuttle. The feeler is also rendered ineffective when turning the loom over by hand, the knock-off arm shown being acted on by the starting handle, when in the off position, in such a way as to withdraw the feeler pin clear of the chopper lever.

CHAPTER IX

SHUTTLELESS LOOMS

Looms which depend on some arrangement other than the usual shuttle, for inserting the weft, are frequently spoken of as shuttleless looms, although very often a kind of shuttle is used, and not infrequently this resembles closely the ordinary shuttle. But the shuttle, if there is one, is only used for inserting the weft as required, and does not carry to and fro any considerable quantity of weft. The weft supply in such looms is generally a large, stationary cone, placed suitably at the back or end of the loom, and from this supply the inserter draws its weft, pick by pick, as required. Unless the weft can be used with double picks in each shed, it is necessary, with such looms, to cut the weft at the selvedges, and this is one of their chief disadvantages. For fabrics that can be woven with two picks in a shed, this method of weaving can be satisfactorily used, a shuttle or hook being used to carry a loop of the weft through the shed. The loop is then caught at the selvedge by a catch cord to bind it, and if a hook has been used this must be withdrawn before the shed closes. This method of weaving is very limited in its application, since the great majority of cloths require only one pick in each warp shed.

Amongst the many attempts made to introduce a loom of this type suitable for most classes of fabrics some mention must be made of the Gawsworth and of the Gabler looms, recently developed in England and Germany respectively. The Gawsworth loom, which was invented by O. Shimwell, inserts picks from each side of the loom alternately, a weft carrier, in the form of a shuttle, taking a pick of weft across from a weft supply at one side of the loom and returning with a pick from a second weft supply at the other side. The weft is accurately cut into two-pick lengths, and consequently only alternate picks are cut at each selvedge, as shown in fig. 54. The other picks bind the selvedge securely, as shown. The cut-weft ends are disposed of as indicated in the cloth section in fig. 54. The end of the weft passes over a tight warp end, and below the others between it and the selvedge. The tight end is kept tending to lift above the surface of the cloth, except when it is lowered for the passage of the shuttle over it, and as weaving proceeds, this end rises slightly from the cloth surface forming small loops, as shown, of the weft ends, and these are sheared off by a cutter blade working level with the cloth surface. The cloth is preferably woven face down, so that these cut weft ends do not appear at all on the cloth face. Although the selvedge is hardly so good as the best selvedges produced by ordinary weaving, they are quite satisfactory for most purposes. In order to keep the selvedges good, it is necessary to use special selvedge motions to move the selvedge threads two up, two down, independent of the weave of the cloth.

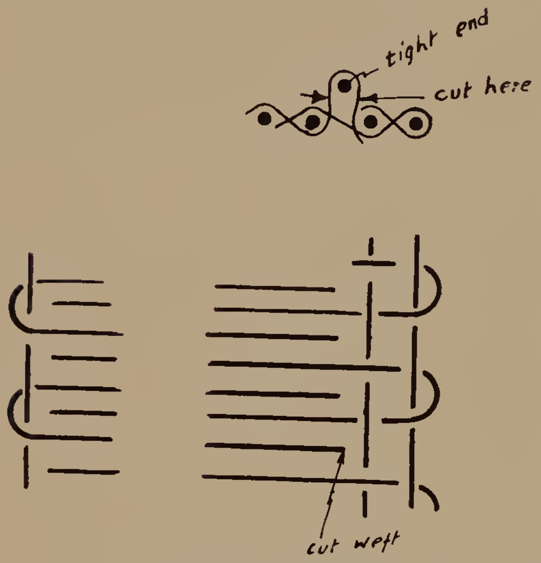


Fig. 54.—Gawsworth Loom—Cloth Section.

The mechanism has been designed to fit as an attachment to any ordinary loom, very few alterations being required, the ordinary picking motion being used to pick across the special shuttle that inserts the weft. The arrangement of the mechanism and its working can be best understood by referring to fig. 55. A weft thread ready for insertion is shown by dotted lines in the plan view at (*a*), the thread passing from a grip G_1, to a peg A near the breast beam, and thence back to a second grip G_2. The length of thread so stretched is exactly that required for two picks. With the weft in this position the shuttle is picked across, and a horn H on it catches the inner piece of weft at W, a knife K_1 cutting the weft close to the grip to allow the weft to go. The shuttle returns with a weft thread drawn from the opposite side of the loom, and on its next journey it takes the outer piece of weft, marked W_1, whilst a knife at K_2 cuts this piece, the peg A having been removed.

A travelling chain is placed at each end of the loom, passing over suitable guide pulleys as shown, and arranged vertically over the end frames of the loom. These chains are driven from the crank shaft and move steadily, their function being to carry the weft threads into position for insertion by the shuttle. The weft threads are drawn into position for insertion by two sets of travelling pegs, which are fixed to the chain. One of these sets of pegs P_1 is shown beginning to draw the weft into position, whilst the other P_2 is travelling round ready to act after P_1. The path of the weft is best seen in the view from the back of the loom, the weft passing from the supply package over a tensioner, through suitable porcelain guides and through a swing-trumpet guide which occupies the position shown, when P_1 is acting, but the dotted position for P_2. The weft is next passed through the grip G_1, which is open, round the pegs P_1, and the end is held in the second grip G_2. Each grip is combined with a knife K_1 or K_2, which can cut the weft close to its grip. These grips and knives are on a rotating shaft, which carries suitable cams for opening and closing the grips and for operating the knives. The grips and knives do not rotate, but their position on the shaft can be varied and their position determines the length of weft inserted, and by this adjustment the length of weft for any width of cloth, within the range of the loom, can readily be got. As the pegs P_1 travel along with the chain, they draw the weft loop forward until the pegs P_1 reach the guide pulley beside the breast beam, when P_1 turns with the chain and disengages from the loop of the weft. The latter is caught, however, by a peg A, which is turned from the horizontal into a vertical position as soon as the travelling pegs have passed. At the same time the grip G_1 is closed on the weft, which is now stretched between the grips and the peg A, and ready for the insertion of the first pick as described above. After

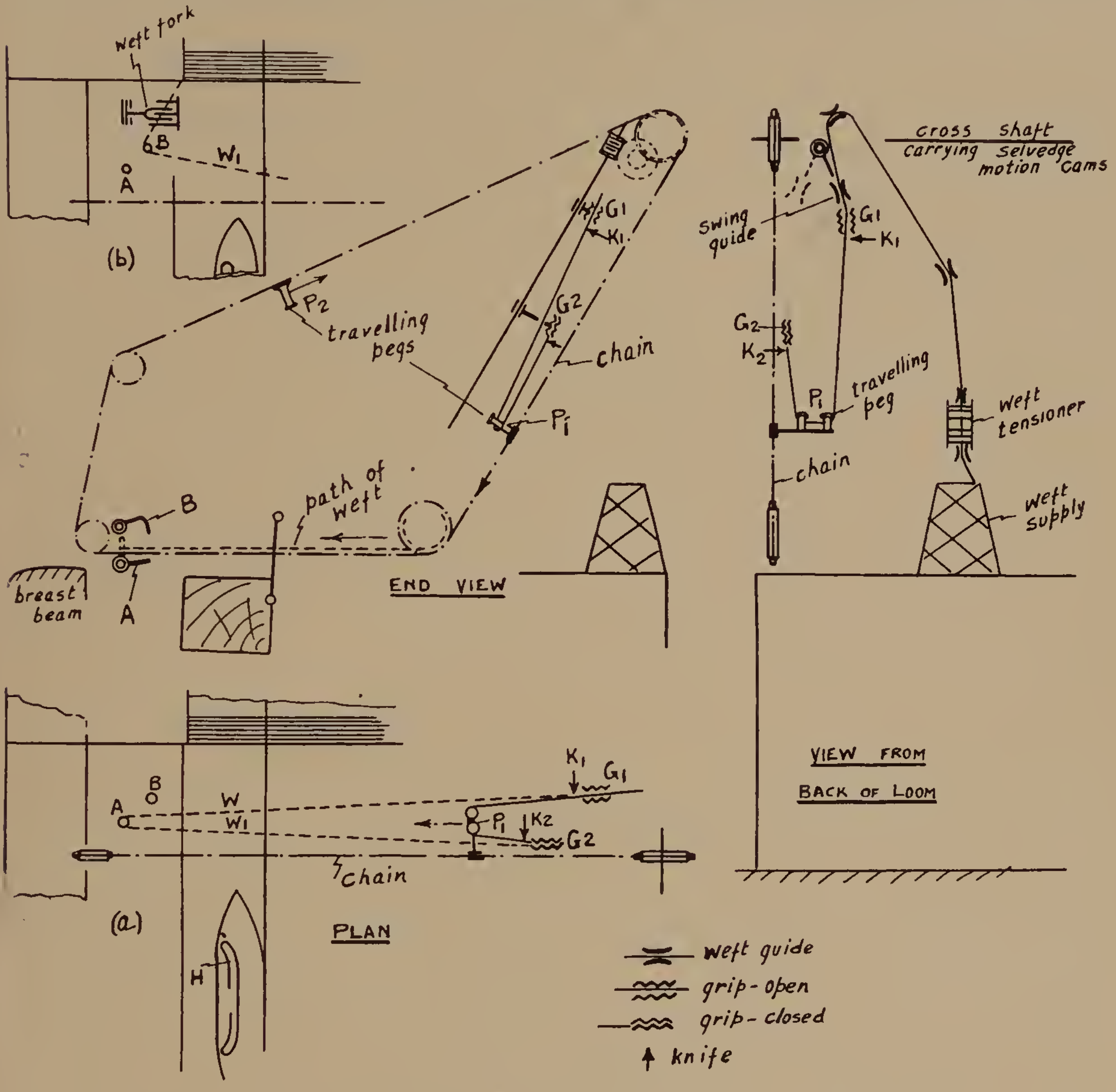


Fig. 55.—Gawsworth Loom—Diagram of the Action.

the first pick has been inserted and beaten up, a second peg B (fig. 55 (*b*)), situated close to A, is lowered so that when A is dropped, the weft loops round B, which brings W_1 within range of the horn on the shuttle. At the same time that the weft is changed from A to B, a fork, which is lightly weighted, is dropped on to the weft between B and the selvedge, tensioning the weft and also acting as a broken-weft detector. If the weft is absent, the fork falls lower than normal, and this is effective for stopping the loom. It will be observed that after the double pick has been inserted, the end of the weft from the supply is gripped at G_1. The swing guide must now be moved over to the dotted position before the next travelling peg P_2 comes round, so that the latter may catch the weft stretching between the swing guide and G_1 and draw the loop forward as before, only this time with the weft end fixed at G_1 and with the grip G_2 open.

This weft-inserting appliance has several important advantages over ordinary looms and automatic looms of the more usual types, but it has not yet been working long enough under mill conditions to see whether these will justify its extended use. The mechanism, entailing the use of the travelling chains, is rather more delicate than is desirable, and the necessary lubrication of these chains and of the guide pulleys is likely to give trouble.

Besides making it possible for an almost inexhaustible weft supply to be used, which enables the number of weavers needed to be reduced very much as compared with ordinary weaving, there are other good points about the loom. The shuttle is so designed that as it crosses it draws the weft under it and so lays it smoothly in the shed, whilst at the same time the weft tension is very small and is regular from pick to pick, which is by no means the case with weft taken from a pirn in an ordinary shuttle. Again, a comparatively shallow shuttle is used, which enables the depth of warp shed to be reduced, and this reduces the number of warp thread breakages. In this connection it should be remembered that the load on a warp thread increases very rapidly as the shed depth is increased, and any reduction in shed depth is very desirable. In the third place the loom automatically mixes the weft, which is very necessary for many high-class cloths, especially self-coloured ones, to prevent stripes due to varying shades of the weft. This feature also enables cloths to be woven with alternate picks of different materials, say cotton or artificial silk, .which is only possible otherwise on complicated and expensive pick-at-will looms of the ordinary type.

The attachment is being used successfully for inserting artificial silk weft at speeds up to about 175 picks per minute, and has been adapted to jute weaving as well as to the weaving of finer fabrics. Although at present confined to tappet looms, the motion can be adapted for use on dobby and Jacquard looms, and when so applied the selvedge motions can be worked from the dobby or Jacquard, which makes the selvedge motion much simpler.

The Gabler loom, like the Gawsworth, draws its weft from two large packages, one at each end of the loom. The weft has to be cut, measured, and tensioned, and it is inserted by means of two picking arms, one at each side of the loom. These arms move inwards simultaneously every pick, meeting in the centre of the warp shed, and then return to their starting position. The end of the weft is taken to the centre of the shed by one arm and transferred to the other, which completes the insertion of the pick, the cut end projecting about an inch beyond the selvedge. This weft end is drawn into the selvedge by the next pick.

Advantages claimed for the loom, in addition to the small amount of attention needed to keep up the weft supply, are reduced warp breakages due to the shallow shed and no oil stains on the cloth. The weft sticks or arms measure only about ¾ inch by 1 inch in section, and require a much smaller shed opening than the ordinary shuttle, whilst there is no picker spindle to lubricate. The majority of automatic looms, however, use pickers that require no lubrication.

Weak points about the loom are that the weft tensioning is difficult to regulate and maintain, partly due to mechanical troubles and partly due to varying atmospheric conditions, whilst the weft cutters, being in continual operation, are difficult to keep in satisfactory working order. It is also difficult to keep the picking arms in good condition, so that the transfer of the weft in the centre of the shed is liable to be unsatisfactory. Moreover, the method of disposing of the cut-weft ends leads to considerable waste of weft, and the extra weft at the selvedge makes it difficult, in many cloths, to drive the picks home.

CHAPTER X

AUTOMATIC LOOMS FOR SPECIAL FABRICS

Most manufacturers of automatic looms make a range of models which are adaptable for a variety of work in different materials, although naturally each is best suited for one or two particular kinds of cloth. These standard looms usually include a light model suitable for cotton, silk, artificial silk, and other light goods, the looms being fitted either with tappets or Jacquards. A change in the framework is desirable for the dobby loom, it generally being deeper to give proper support to the dobby. For heavier cotton cloths, and for woollen, worsted, linen, etc., a somewhat heavier model is provided, whilst a yet heavier loom is made, generally fitted either with tappet or positive dobby, suitable for the woollen and worsted trade, for coatings, gabardines, etc. The light type of loom is generally a single-shuttle loom, but very often two shuttles are provided in the others for weft-mixing purposes. Another usual model is a heavy sheeting loom, suitable for cotton sheetings, woollen blankets, quilts, linen damasks, etc., up to about 120 inches wide, a model which is generally provided with tappets or arranged to work with Jacquard shedding. The two- or four-colour check or gingham looms usually complete the range of models, any one of which is capable of being used for a considerable variety of work. In addition to these, automatic looms are generally made which are confined fairly strictly to one class of fabric. The most important of these are looms for fustian weaving; extra heavy looms for heavy canvas, duck, and cord-tyre fabrics; and looms for weaving terry towelling. These looms generally have the characteristics which have been found most suitable for weaving cloths of these types. The fustian looms are of strong construction, and are generally fitted with positive outside tappets or with a dobby motion. The outside tappets in the Northrop fustian loom are arranged with the tappet shaft at right angles to the crank shaft, an arrangement which is fairly common on continental looms, but is not generally favoured by British loom-makers. The tappets take up a little more floor space than in the more usual arrangement and require a bevel-wheel drive, but the connection between the treadle levers and the heald shafts is much more direct, as will be seen from the sketch of the arrangement in fig. 56. An automatic let-off motion is generally fitted, but some manufacturers prefer the lever-and-weight type, which can generally be fitted if required. The take-up is different from the usual positive ratchet-wheel type, a negative motion being used in preference, or a positive worm-wheel take-up. This must be designed to enable a high number of picks per inch to be inserted, and generally allowance is made for a range from 50 to 400 or 500, whilst a crack preventer eliminates thin places by disconnecting the motion when the weft breaks or happens to run out.

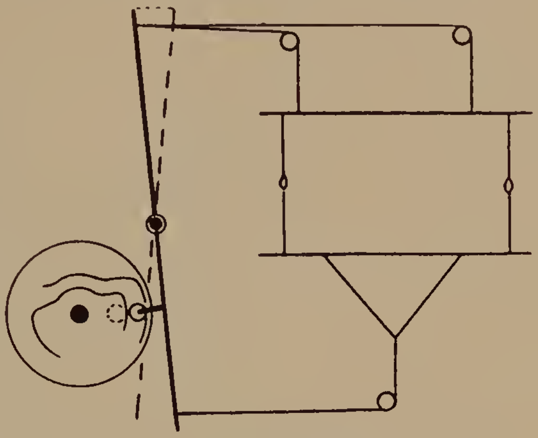


FIG. 56.—POSITIVE SHEDDING FOR FUSTIAN LOOM.

The heavy-weight looms for canvas, duck cloth, cord fabric for tyres, etc., differ considerably in design from the lighter looms. In the past much trouble has been caused to manufacturers through looms for these fabrics being often built too light to stand the great stresses to which they are subjected, and some of the automatic looms brought out for this work have not been free from these faults. These can only be eliminated by a careful study of the forces to be dealt with during the weaving, and equally careful design of the loom to withstand them. Judging by some of the results, loom designers in the past have not always been able to deal satisfactorily with these problems. The warp tension is generally very high, which necessitates a strongly built framework, whilst the driving crank shaft must be of ample strength to overcome the warp tension at beat-up. A strong and rigid slay is required for the same reason, and as the looms are often fairly wide, an eccentric motion of the slay is desirable to give an easy pick and the benefit of some increased speed of the slay at beat-up. This is a feature which is not to the advantage of a cop-changing loom, where the slay movement during the transfer is preferably as slow as possible, and the cop-changing wide loom will, as a rule, be found to have less slay eccentricity than is desirable for the picking and beat-up. Other parts that want special attention are the shedding motion and the let-off motion, and it is doubtful whether an automatic let-off with a sensitive back-rest is satisfactory for this heavy work. The Northrop heavy loom is fitted with a chain friction let-off, loaded by weights acting through compound levers, whilst a powerful fixed back-rest, made of steel tubes, is well able to withstand the great tension in the warp. The driving of this loom is done by a powerful cone clutch, geared to the loom-driving shaft. A reverse drive is also provided if desired, which enables the weaver, through operating a simple foot-pedal, to reverse the loom by power. A weft-grabbing motion is used on this loom, the weft grabber consisting of an arm which is moved in at transfer to pass over the old weft between the shuttle and the ejected bobbin, the grabber drawing the end of the old weft clear and preventing it from being drawn into the cloth.

These heavy looms are sometimes arranged with a special creel behind the loom, the warp ends being drawn direct from warpers' bobbins arranged in the creel. Again, the take-up is often arranged clear of the loom, and takes the form of a special batching-on arrangement which permits of the building up of a cloth roll of 4 to 5 feet in diameter.

It will be realised that shuttle-changing looms have advantages for this type of work, always provided that the general design of the looms is satisfactory. The Stafford heavy loom works on the same general lines as the light loom, the method of changing the shuttle being practically the same. Another shuttle changer for duck cloth and tyre fabric is that made by Messrs Crompton & Knowles, who depart from their general practice of using cop-changing mechanism by fitting their heavy looms with a shuttle-changing device. This operates with the loom running at full speed, the shuttle with the nearly empty bobbin being ejected into a receiver, from which it slides into a chute at the front of the loom, whilst at the same time a shuttle with a full bobbin is inserted in the box. The steady beat of the slay, due to the change taking place without stopping the loom, is less liable to give thick and thin places where the change of weft has taken place.

Automatic terry-towel looms are fitted with the usual equipment for terry weaving. The shedding motion is generally a dobby, very often of the cross-border type, to enable patterned headings to be put in, whilst a Jacquard may be fitted, if necessary. In addition to the terry motion itself, an automatic fringing motion is usually fitted for putting in any required length of fringe between towels, this consisting in some arrangement for accelerating the action of the uptake, whilst at the same time releasing the let-off motion. The dobby is preferably used to control the change over from terry to plain weave, and for starting and stopping the fringing motion, although these changes may be controlled from the box-motion chain, if one is used, or from a separate measuring motion. The let-off motions also require controlling, the terry warp being slack whilst forming terry and tightened up for the plain portions, whilst the ground warp is normally tight and requires release during fringing. The let-off is frequently of the negative friction type, fitted either with chains or ropes, but on the Northrop loom the ground warp let-off is of the automatic type, whilst on the Crompton & Knowles loom a special positive terry let-off is used on the terry warp beam to give uniform length of pile. A warp stop motion is generally applied only to the ground warp, since breakage of the pile warp threads, which are often two-fold, is rare. In the majority of terrys two or more colours or kinds of weft are needed, since coloured borders are commonly used, and, still more commonly, cord headings formed by picks of thick weft. Consequently, the automatic terry loom is often required to be a multiple-box loom, generally for two shuttles, although four are sometimes used. The Northrop multiple-box equipment is a two-shuttle motion, together with a two-colour magazine with electrical control. The Crompton & Knowles terry loom may be fitted either with a two-shuttle or a four-shuttle motion, the former being often used in conjunction with a four-cell magazine. This is of great advantage when, as is commonly the case, the body of the towel is of one colour and the border of another. In these circumstances, the body of the towel requires much more weft than the border, and to allow for this, the four-cell magazine on the two-shuttle loom is arranged so that one cell carries the border colour whilst the other three take the body weft, the three cells being drawn on in sequence when a bobbin is required for transfer, in this way distributing among the three cells the requirements that would otherwise fall on one.

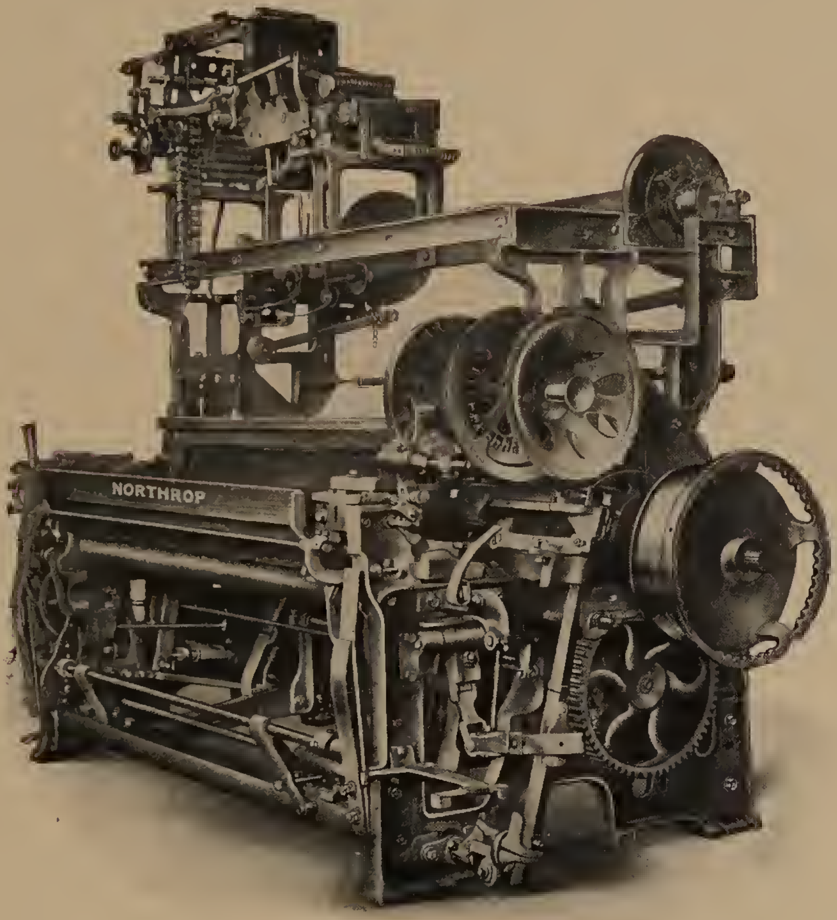


Fig. 57.—Northrop Automatic Terry Loom.

CHAPTER XI

WARP STOP MOTIONS

Warp stop motions were invented and used long before the automatic loom, Dr Cartwright in 1786 patenting a motion for his loom, a motion which embodied the general principles of the most successful stop motions in use at present. But it was not until the automatic loom began to be used on a considerable scale that warp stop motions were used to any extent. Now that they have been improved for use on automatic looms, they are being applied to other looms as well, resulting in the weaver being able to supervise a greater number of looms than before, and in the production of better cloth, due to the loom stopping immediately a warp thread breaks. This not only prevents floats, but prevents the broken warp thread from becoming entangled with others beside it, interfering also with their working. The warp stop motions that are now by far the most commonly used, have a metal detector or drop wire suspended on each warp thread and normally supporting the thread. If the latter breaks, the detector drops and causes the loom to stop. There can be no doubt that the passage of the warp threads through the drop wires chafes the threads to some extent, and that a warp of very fine and delicate material on the one hand, or of coarse and irregular material on the other, frequently gives trouble with the stop motion. It may at times be possible to weave such warps in an ordinary loom when it could not be done with the automatic, owing to this difficulty at the stop motion, and also to the fact that the automatic loom generally has a larger shuttle than the ordinary loom, needing a deeper shed. Whilst this is true, it would generally pay the manufacturer, in these exceptional cases, to use rather better yarns, the saving in weavers' wages and the better cloth produced more than balancing the slightly higher cost of the material.

Stop motions have been devised using metal healds instead of drop wires, the warp threads supporting the healds at one point in the heald-shaft movement, a broken warp thread allowing its heald to fall into contact with a reciprocating bar, which stops the loom by a connection to the starting handle. In another type the completion of an electric circuit, when a warp thread breaks, is utilised to stop the loom. Each pair of adjacent warp threads, where they pass each other at the lease, are crossed so as to hold a spring wire out of contact with a metal bar, which forms part of the circuit. If one of the two warp threads breaks, the wire is released and springs into contact with the bar, completing the circuit and causing the loom to stop.[1] But, as already stated, these types are very little used in comparison with the drop-wire motion.

Fox, in his *Mechanism of Weaving*, states that "an efficient stop motion must have a wide range of application; it must be readily adaptable to different types and different widths of looms, to different materials, to varied counts of yarns, and to fabrics requiring two or more warp beams." It might be added that the working parts of the motion, particularly those requiring adjustment, should be readily accessible, a feature that was not always appreciated by the makers of the earlier stop motions, but which is now generally, though not always, attended to in modern types.

One of the most successful types of stop motion has the drop wires suspended over three slotted bars (fig. 58), the outer pair of bars being fixed, whilst the other normally reciprocates between them. If a thread breaks, the detector drops and locks the bars so as to stop the reciprocating one, this being made possible by some type of flexible driving joint which is normally strong enough to reciprocate the bar or bars, but yields when a bar is locked. The joint, when it yields, acts in one way or another on the starting handle and stops the loom. This motion lends itself better than most others to the fitting of more than two banks or rows of drop wires, which is desirable for fine warps, to prevent overcrowding which tends to cause the wires to stick. By having the bars above the warp they are in a position where they do not collect much dust and fluff and are more easily kept clean than when they are below the warp.

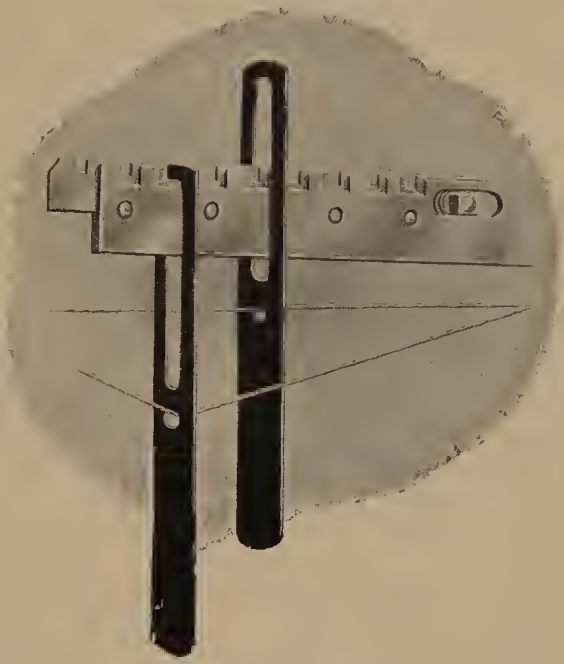


FIG. 58.—SLOTTED BARS OF NORTHROP WARP STOP MOTION.

The action of the Hattersley stop motion, which is of this type, is illustrated in fig. 59. The moving bars are reciprocated by lever connections from a crank, driven from the bottom shaft. The lever arm which drives the moving bar or bars is made in two parts, one fast to a rocking shaft, whilst the second part, which drives the bars, is normally kept fast to the first by a spring-loaded locking lever, the end of which rests in a V recess in the fast part. If a bar is locked by a detector, the resistance causes the side of the V recess to cam the locking lever out of the recess, lifting it against the action of the spring. The end of the locking lever is attached by cable to a knock-off lever mounted on the starting handle of the loom. If this knock-off lever is lifted by the locking of a stop motion bar, the lever end comes in contact with an adjustable

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[1] For description, with sketch, see Fox's *Mechanism of Weaving*.

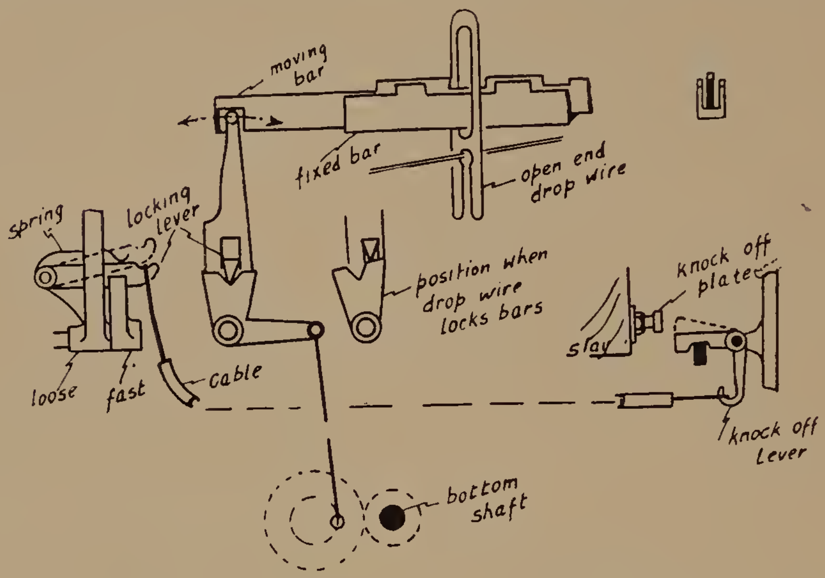

FIG. 59.—HATTERSLEY WARP STOP MOTION.

knock-off plate on the slay, as the latter beats up, and the starting handle is knocked out of its retaining slot, thus stopping the loom. The motion is simple and effective, and the driving gear is compactly arranged under the warp, a position, however, that is rather inconvenient for adjustments.

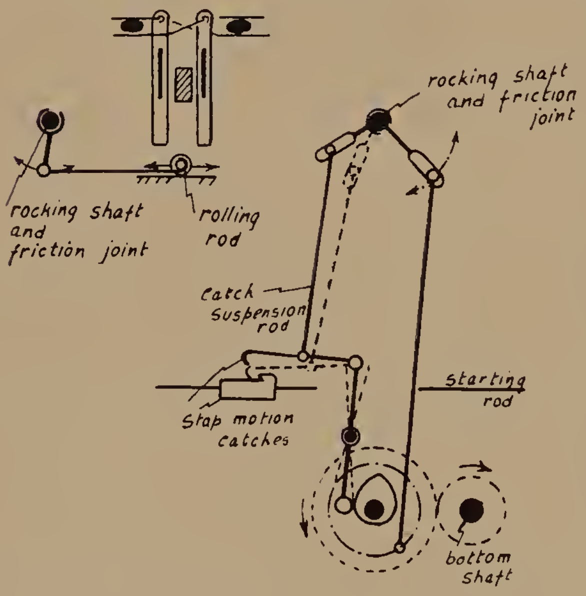

FIG. 60.—STAFFORD WARP STOP MOTION.

STAFFORD STOP MOTION.—The action of this motion is illustrated in fig. 60. The drop wires are suspended on the warp threads, between the lease rods, and below the drop wires a round rod rolls to and fro horizontally, this rod getting its movement from a lever fixed to a rocking shaft by a friction joint. If a detector drops, it gets in the path of the rod and is sufficient to cause the friction joint to slip and so stop the rod in the middle of its movement. The rocking shaft gets its movement from a crank which is driven by reduction gearing from the bottom shaft of the loom. Compounded with the crank is a cam, which gives a rocking motion to a lever which carries one of the stop-motion catches at its upper end. This catch is suspended by a rod from a lever on the rocking shaft, and this lever is connected to that which drives the rolling rod, so that when the latter stops, the catch suspension rod also stops, in the position shown dotted. The top catch receives a reciprocating motion from the cam and at the same time is lifted and lowered by the suspension rod. Normally, when the top catch is just over the lower one, which is fixed to the starting rod, the top catch is lifted clear by the suspension rod. When, however, the latter is stopped in the dotted position, through the falling of a drop wire, the catches engage and the starting rod stops the loom. This motion is a very simple one and is used successfully on both very fine and very coarse warps. The friction joint, together with the driving links and catches, are outside the loom framework in a position where any necessary adjustment can very easily be effected.

Ruti Stop Motion.—This motion is typical of a slightly different class, which is frequently used both by British and other loom makers. An oscillating knife frame (fig. 61) moves to and fro below the drop wires, the frame receiving its motion from an eccentric, and swinging to and fro about a fulcrum F. This fulcrum, however, is not rigidly fixed, but is mounted on a rod which is connected up by levers to the starting handle of the loom, in such a way that, if the fulcrum F is displaced, the starting handle is pushed over to stop the loom. If a drop wire falls, it enters the slot in the centre of the oscillating frame, and this locks the frame top against a fixed bar in the drop-wire frame, with the result that, since the top is held, the bottom part, *i.e.* the fulcrum F, must yield, and the resulting movement of F is used, as explained, to stop the loom. In this motion most of the working parts are below the warp, which is rather a disadvantage.

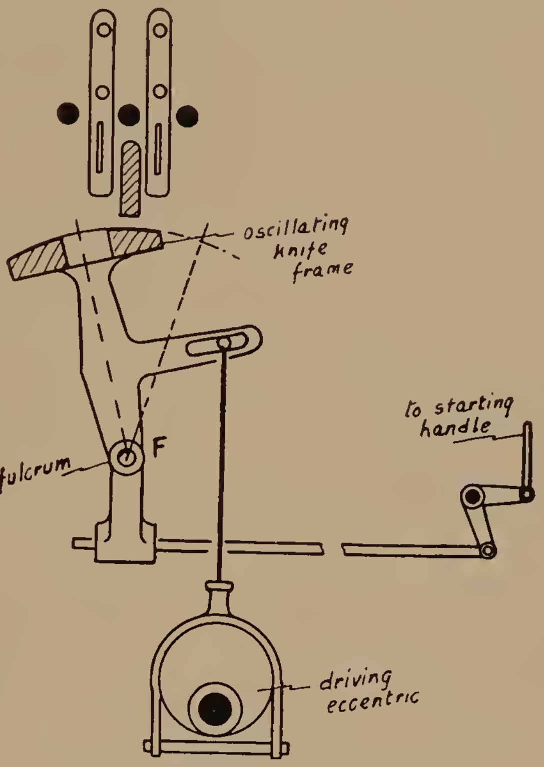

Fig. 61.—Ruti Warp Stop Motion.

Messrs Ruti also make a motion of the sliding-bar type, in which the bars are placed above the warp and which is suitable for use with either open or closed drop wires.

Normally an eccentric on the bottom shaft causes a rod to rise and fall between the slay and the breast beam. This vertical rod slides in an eye attached to the weft fork lever, and the rod carries a projecting piece which is normally above or below a corresponding projection on the slay when the latter beats up. If a drop wire locks the slide bars, the sliding rod is also locked in the middle of its movement, so that the projection on the slay meets that on the rod, and the weft fork lever causes the starting handle to move to the "off" position.

CHAPTER XII

AUTOMATIC LET-OFF MOTIONS

Although not invariably fitted to the automatic loom, an automatic let-off motion is highly desirable, and should be considered to be essential. Without it, the weaver is responsible for keeping the warp tension constant and the cloth width correct, and if the weaver has many looms to supervise, this work is liable to be done indifferently, resulting not only in variations in cloth width, but in banging-off of the looms, lowering the efficiency of running and increasing the repair bill. Not only so, but the weights used on the friction let-off, which is almost universally used when no automatic motion is fitted, are heavy, and frequent lifting of these is unsuitable work for female labour. This work is bad enough with ordinary looms, where the weaver has, at the most, four looms to look after, but it is intolerable if the weaver has, say, sixteen looms to keep running. Undoubtedly the friction let-off is easy on the warp, and for some weaves, particularly plain cloth, the give and take movement of the warp beam, with this kind of let-off, keeps the warp tension more regular than most automatic motions and gives better covered cloth.

The majority of the automatic motions are of the semi-positive type in which the beam is turned by gearing, but at a rate which varies with the tension on the warp. The warp passes over a sensitive back-rest, which is generally spring loaded to resist the warp tension, although sometimes weights are used instead of the springs, and the movement of the back-rest is used to regulate the rate of letting-off. Sometimes modifications of the lever and weight type are used, and most makers of automatic looms continue to experiment with these motions, which seems to indicate that those generally fitted are not considered to be entirely satisfactory. Often, also, different types are fitted by the same makers either to meet the preferences of different sections of the weaving industry or to suit varying kinds of cloth.

Northrop Let-off Motions.—The usual let-off motion for the Northrop loom is the Roper motion, illustrated diagrammatically in fig. 62. The beam is driven by gearing from a ratchet wheel, which normally makes a partial turn for every to-and-fro movement of the slay. A pin fixed to the slay normally engages with the right-hand end of the slot in the driving link and turns the ratchet two or three teeth. When the pin moves to the left, the parts are left free. The warp tension, acting on the sensitive back-rest, now overcomes the force of the warp-tension spring and, acting through two levers A and B, moves the ratchet pawl back over several teeth drawing the link to the left. The amount of this movement naturally depends on the warp tension; if high, considerable movement results; if the warp tension is low, little if any of this backward movement takes place, and the pin on the slay simply slides to and fro in the link slot, until the warp tension increases through the take-up pulling the cloth forward. The movement thus adjusts itself to the warp tension, and it will be seen that slackening off the tension spring will result in reduced warp tension, since the warp can more easily deflect the back-rest and move the ratchet lever. The spring is adjusted at the beginning of a new warp, if necessary, and after that no further attention should be needed during the weaving down of the warp. An epicyclic speed-reduction gear is introduced between the ratchet wheel and the driving pinion, so as to give a reasonable ratchet movement for the small amount of beam movement required per pick. The number of teeth normally taken by the ratchet pawl is also increased, automatically, as the beam weaves down. A feeler on the beam changes the position of the connecting pin between levers A and B, bringing this pin nearer to the fulcrum of B and farther from the fulcrum of A. Thus, at the empty beam, a given deflection of the back-rest gives a greater angular movement of the ratchet lever than at the full beam, resulting in a greater angular movement of the beam to compensate for the smaller diameter.

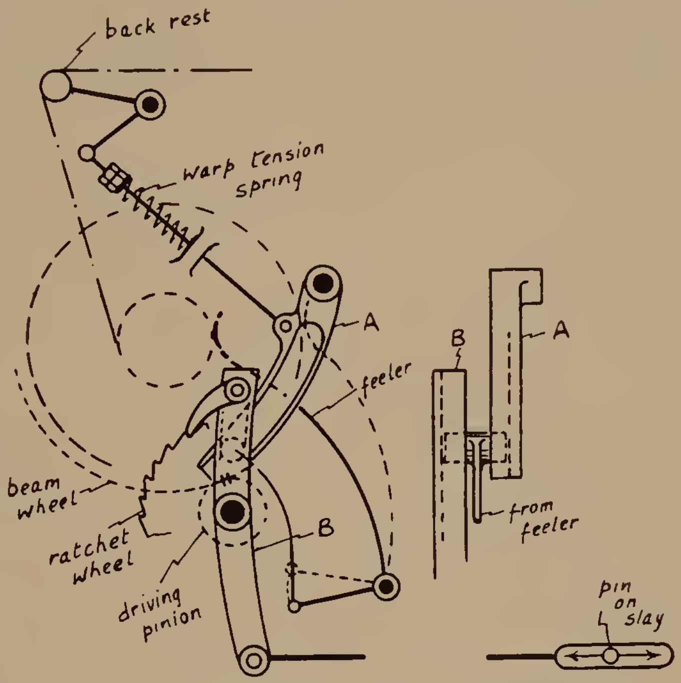

Fig. 62.—Roper Automatic Let-off Motion.

This motion depends for its accuracy on the assumption that the turning effect of a constant warp tension on the back-rest lever is the same at full beam as at empty beam. This is not quite the case, for the effect of the resultant R_1 (fig. 63) of a given warp tension at empty beam is not quite so great as the effect of the resultant R of an equal tension at full beam. Thus the yarn tension will require to be slightly greater at empty than at full beam to overcome the spring tension, but the difference is small.

Another motion which is used on Northrop looms, and is rather heavier in build, is the Bartlett motion (fig. 64), which acts on the same general principle as the Roper motion. Again, a pin on the slay normally turns a ratchet wheel, which turns the beam by means of a worm and worm wheel. The pin on the slay causes a sleeve to slide to and fro on the ratchet driving rod, and gives movement to the latter when the sleeve comes in contact with a collar fixed to the rod. The position of the collar depends on the tension of the warp, the ratchet driving rod being connected to the sensitive back-rest, a spring again forming the resistance and regulating the tension of the warp. A hand wheel, on the release of a band brake, enables the beam to be turned by hand.

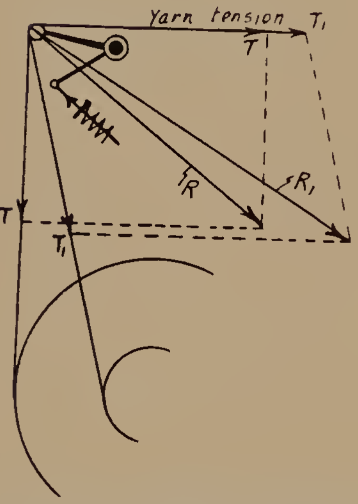

Fig. 63.—Diagram of Yarn Tensions in the Roper Let-off.

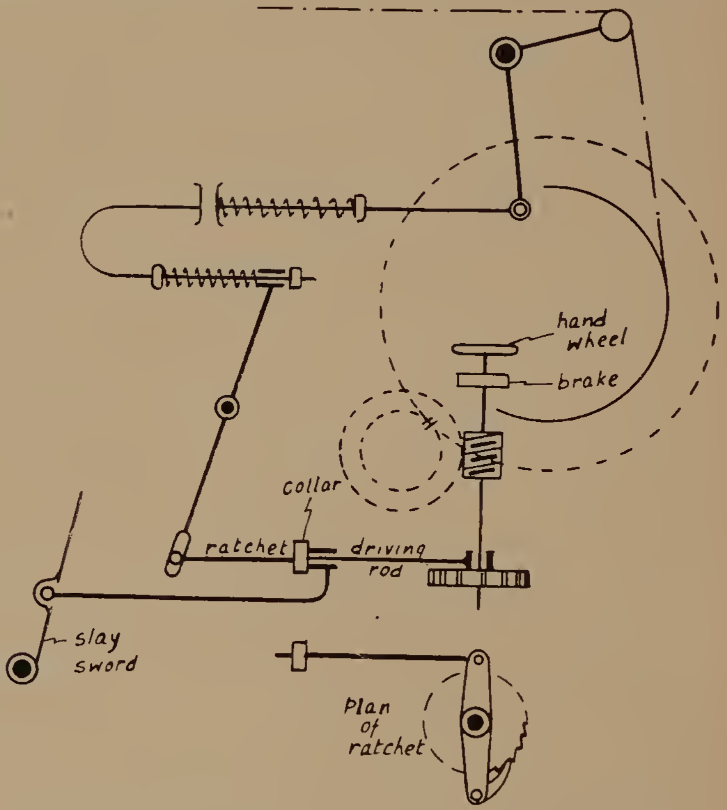

Fig. 64.—Bartlett Automatic Let-off Motion.

A modification of the well-known Hutchinson Hollingworth semi-positive motion[1] is sometimes fitted to Northrop woollen and worsted looms. This acts on the same general principle as the motions just described, but the back-rest is balanced and the warp tension regulated by a weight and lever, instead of by the spring.

A motion which resembles the Bartlett motion is that used on the Ruti looms and shown by the diagram in fig. 65. Motion is given to the beam in a similar way, the main difference being the addition of a feeler motion which acts on the beam and varies the amount of turning of the beam according to its diameter. As the beam diameter decreases, the feeler lowers a wedge between the sliding and fixed collars on the ratchet rod, with the result that the amount of lost movement between the sliding and fixed collars is reduced as the beam weaves down, and hence a greater ratchet movement results from a given deflection of the back-rest.

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[1] See *Mechanism of Weaving*, T. W. Fox; or *Jute and Linen Weaving*, Woodhouse and Milne.

The Stafford motion is again very similar, and is shown in fig. 66, but the feeler acts in a different way in this loom, and has a somewhat different effect. It will be seen that, as the beam decreases in diameter, the action of the feeler is to reduce slightly the strength of the spring. This is theoretically correct, as explained above, in order to keep the warp tension constant. The increased movement, needed to compensate for the smaller beam diameter, is left to the action of the sensitive back-rest, as it is in the Bartlett motion, and it is doubtful whether it is necessary to help the back-rest by a feeler motion to vary the rate of turning of the beam.

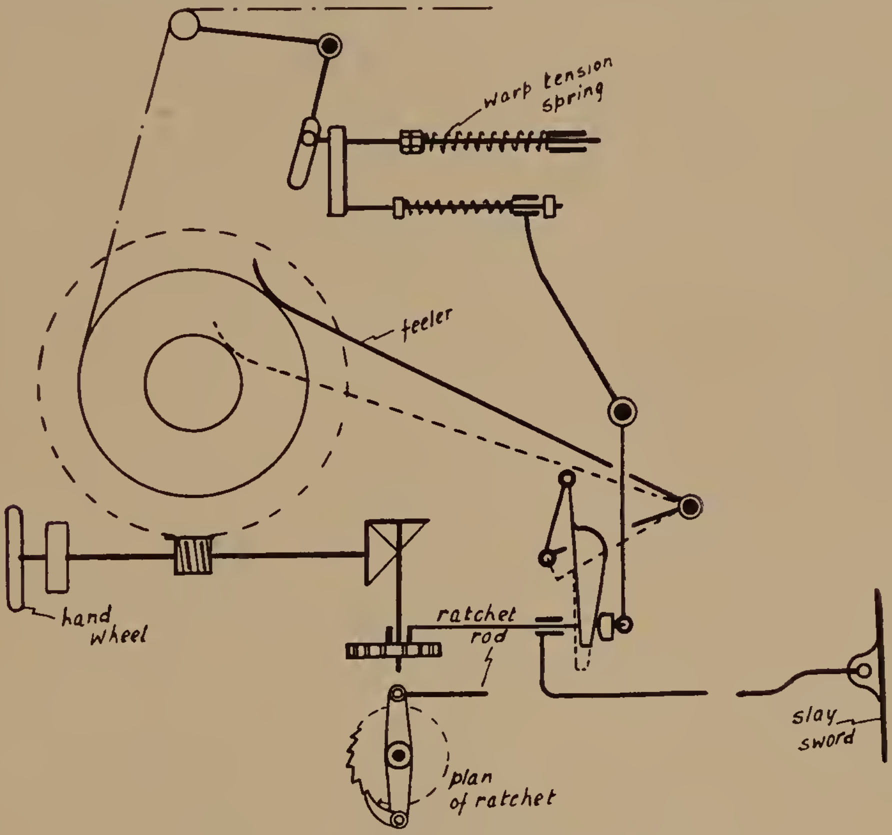

FIG. 65.—RUTI AUTOMATIC LET-OFF MOTION.

The Hattersley loom relies on a modification of the usual lever-and-weight friction let-off. The weight is a comparatively small one, and is mounted on rollers so that it can readily move along the lever, and the yarn tension is kept constant by the weight being moved automatically nearer to the lever fulcrum as the beam weaves down. It is easy to prove that, for constant tension, the

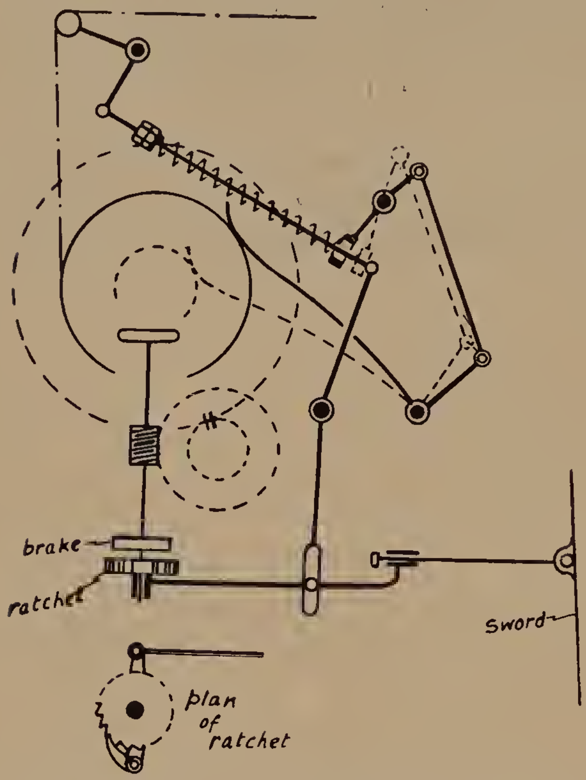

Fig. 66.—Stafford Automatic Let-off Motion.

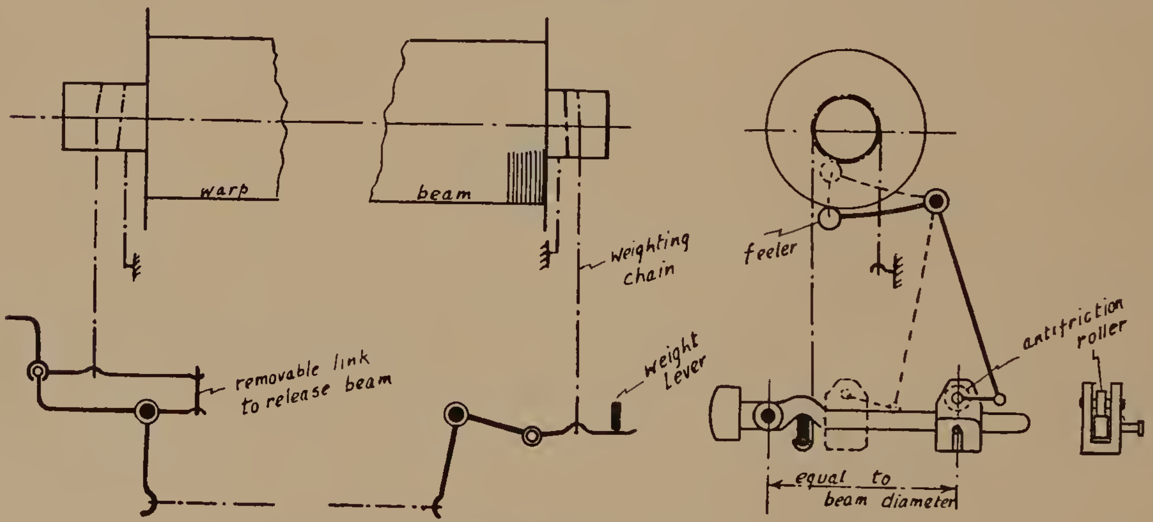

Fig. 67.—Hattersley Automatic Let-off Motion.

distance of the weight from the fulcrum must be directly proportional to the beam diameter, and this is ensured in this motion by balancing the lever when the weight is removed, and then arranging that the distance of the weight from the lever fulcrum will always be the same as the beam diameter. This is effected through the action of a feeler, pressing against the yarn on the beam. Through lever connections this feeler acts on the weight, and automatically moves it as stated. Change in the warp tension, to suit different cloths, is got by varying the weight, which can readily be done by slipping additional weights on to the side of the main weight. The lever and weight is fitted at one end of the loom only, acting at that end on a bell-crank lever, one arm of which applies the load to the chain which is coiled round the ruffle, whilst the other conveys the load to the weighting chain at the other end of the loom (fig. 67). This loom is fitted with a warp-easing motion for plain cloth, the usual arrangement of an eccentric on the crank shaft, moving the back-rest so as to compensate for the effect of the shedding on the warp tension. This device, which is commonly used on ordinary looms, is not often fitted to automatic let-off motions, and the sensitive back-rest is left to counteract the varying stresses due to the shedding. This entails a considerable amount of movement on the part of the sensitive rail, which interferes to some extent with its function of regulating the rate of let-off, and the addition of a warp-easing rail is certainly desirable for looms weaving plain cloth, particularly looms weaving linen and similar yarns which stretch but little with increase of tension. A full description of such a motion, frequently used on plain linen looms, is given in Woodhouse and Milne's *Jute and Linen Weaving*.

Another modification of the friction let-off is the Scholes motion (fig. 68).

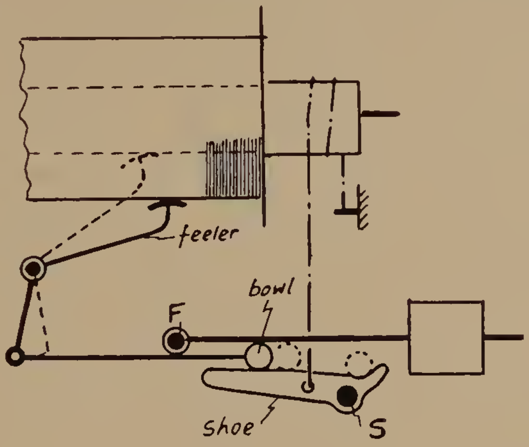

FIG. 68.—SCHOLES AUTOMATIC LET-OFF MOTION.

In this type the weight occupies a fixed position on the lever, although its position can be adjusted to vary the warp tension for different warps. The weight does not act directly on the weighting chain or rope, but through a movable bowl which fits between the lever and a shoe to which the chain is attached. A feeler on the warp beam moves the bowl further from the fulcrum F of the lever and nearer to the fulcrum S of the shoe as the beam empties, both of these actions reducing the pull on the loading chain, and, by properly proportioning the parts, the warp tension is kept constant. The bowl is arranged so that it can readily be moved by hand, if desired, and by moving it to the dotted position, on the other side of the fulcrum S, the load is entirely removed from the chain, and the beam can readily be adjusted by hand.

CHAPTER XIII

YARNS AND YARN PREPARATION FOR THE AUTOMATIC LOOM

THE question as to whether or not automatic looms need better yarns and preparation than ordinary looms is one which has often been discussed. There can be no reasonable doubt that, in general, the warp yarns and preparation used in ordinary looms can be used in automatic looms, but that very often some improvement in yarn quality, and in the preparation, would repay the extra cost, by enabling the weaver to look after a greater number of looms, and by giving slightly better cloth. It is also generally admitted that, occasionally, warps of delicate and weak yarns are met with, which will not stand the use of the warp stop motion, but which can, although with difficulty, be woven on the ordinary loom. So far as weft yarns are concerned, it is claimed, and with reason, by makers of shuttle-changing looms, that their looms, using ordinary shuttles and hand threading, are no harder on weft than the ordinary loom. With cop-changing looms the conditions are rather different, the yarn being subjected to a certain amount of drag during the changing and threading operations. But again, even with shuttle-changing looms it will often pay to use a rather better weft than is commonly used for similar cloth on the ordinary loom, in order to reduce the number of stoppages for weft breakages.

In the cotton-weaving industry the yarns are sometimes ring spun and sometimes mule spun. Much depends on the method of preparation adopted and on whether the yarn is spun at the mill or has to be bought outside, as to which kind of yarn is the more suitable. Warp yarn, prepared by the ordinary methods, may be either ring spun or mule spun, since winding to warpers' bobbins can be done equally well from ring bobbins or mule cops. When warp yarn is bought from outside, mule cops are bought if the manufacturer wants to do his own preparation; on the other hand, the yarn can be bought on back beams prepared by the spinner, and for these conditions either ring- or mule-spun yarn may be used, depending on the spinner's plant. Many manufacturers prefer to prepare their warps from cops, as they are then sure that the yarn has been properly cleared and freed from faults. For the Barber-Colman system of winding and warping, ring-spun yarn is practically essential, since the production is seriously reduced if mule yarn is used. For weft yarn, particularly with cop-changing looms, ring-spun yarn has a great advantage, and these looms are, consequently, best suited to mills which combine spinning with weaving. The weft can be spun direct on bobbins suitable for the shuttles, which reduces the work of the battery fillers to a large extent, compared with skewering cops, besides reducing the amount of waste made, and, on the other hand, is considerably cheaper than having the weft rewound on to pirns.

Automatic looms show to best advantage on standard cloths, where changes are not too frequent. Prices are keenly cut in such cloths, and even a small saving due to the use of automatic looms may be of great importance. The preparation systems suitable for such cloths are naturally those which lend themselves best to mass-production methods. For warp preparation, the chief desirable features are that the system should produce good weaving warps and be thoroughly reliable, so that the maximum loom efficiency will be attained. Although it is important that preparation costs should be kept as low as possible, it must be remembered that preparation costs are relatively very small as compared with weaving costs.

The alternative systems available for grey cotton warp preparation in large quantities are: (1) the ordinary Lancashire system of upright-spindle winding to warpers' bobbins, beam warping, and slasher sizing; (2) the American slow-speed system; (3) high-speed warping systems; (4) the Barber-Colman system. The American slow-speed system uses the same, or practically the same machines as the first system, but differs in the warping machines being run at a somewhat lower speed, and in one warper supervising three or four machines instead of one as in the first system, creelers being employed in the American system to creel the bobbins. High-speed warping systems use high-speed beam warping machines, working at speeds ranging from 200 to 500 yards per minute, and warp either from stationary bottle-shaped bobbins or from cones. These packages hold much more yarn than the ordinary warpers' bobbins, and one creeling suffices for filling several beams. The bottle-shaped bobbins are wound on an upright-spindle machine, which may be converted from one of the ordinary winding machines for warpers' bobbins; cones are generally wound on a drum-winding machine, the rate of winding being much higher than that of the ordinary bobbin winder. The Barber-Colman system of winding uses an automatic winder, which winds from roving-built ring bobbins to small cheeses which are formed on ball-bearing centres, these cheeses rotating in the creel of the warping machine. The winding machine is an intricate and ingenious one, with a high production and requiring very little attention from the operative, but a set of cheeses holds only enough yarn for one beam. The warping machine warps at 500 yards per minute, and is only suitable for use in conjunction with the special winding machine.[1] An approximate comparison of costs for these systems is made in Appendix I, which goes to show that the

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[1] For a detailed description of the Barber-Colman system, see *The Textile Manufacturer*, October 1927.

Barber-Colman system is by far the cheapest, whilst there is a considerable but not very great saving to be expected by using the high-speed warping systems. The chief item in winding and warping costs is that of winders' wages, and unless that is materially reduced, the saving due to any other cause can only be small. Although the Barber-Colman system works out well, when compared for costs with other systems, there are points to be noted against it, especially for the conditions prevailing in the Lancashire cotton trade. The system is only suitable for comparatively large plants, and entails a considerable capital outlay. The winding machine in particular is intricate, and it is doubtful whether it can be kept running with that degree of regularity and certainty that is essential for the manufacturer. The other systems, particularly the ordinary Lancashire system, use machines that are simple and cheap, so that delay due to breakdown of machinery is almost unknown. Further, as already mentioned, the Barber-Colman system is practically limited to using ring-spun yarn, and that on roving-built bobbins. The latter is perhaps not a serious difficulty, but many manufacturers certainly prefer mule-spun yarns for much of their work and will prefer the other methods. The Barber-Colman system is well suited for grey work in large combined spinning and weaving mills, provided it proves to be reasonably free from breakdowns, and it should also prove suitable for spinning mills which prepare yarn on the back beam for sale to manufacturers. A temporary stoppage of the winding machine in such a mill, although serious, would not have so far-reaching effects as where the winding machine forms one link in the chain between cop and cloth. It is at present somewhat doubtful whether the comparatively small saving that can be effected through using the Barber-Colman system will prove to be sufficient to justify its use, but it seems likely that the use of automatic looms on standard cloths is bound up with yarns prepared by this system, which is the only one that promises to reduce materially the greatest item in preparation costs, viz. winders' wages.

Whatever system of winding is used, it is desirable that the warp yarns should be cleared sufficiently to break down any weak or thick places that otherwise are practically certain to cause a stoppage at the loom. The earlier these places are eliminated the better, and it is certainly cheaper to remove them at the winding frame, where only the one thread in question is stopped, than at any subsequent process, where the working of 200 to 2000 or more threads may be interrupted whilst one is being repaired. It is also desirable that mechanical knotters should be used, on account of the smaller knot tied as compared with the hand-tied winder's knot, the latter being more likely to cause trouble at the warp-stop-motion drop wire and at the heald eyes and reed.

The slasher-sizing machine, which is almost universally used for grey warp preparation for ordinary looms, is equally suitable for warp preparation for automatic looms. The cylinder-drying type of machine is the one still generally preferred, although for fine warps at any rate there can be little doubt that hot-air drying gives better results, as it also does for heavily sized warps in which the threads are liable to stick together with cylinder drying. Mechanical drawing-in and knotting machines are generally desirable where the conditions favour their use, the drawing-in machine being limited in its use to warps for cloths of a fairly simple character, cloths, however, which form the bulk of those suitable for weaving in automatic looms.

Grey cotton weft undoubtedly gives the least trouble in automatic looms when on ring-frame bobbins or rewound pirns. For cop-changing looms, ring-frame weft is spun on special bobbins suitable for use in the magazine and shuttle of the loom. The bobbins are larger than ordinary ring-frame weft bobbins, since the cop-changing loom generally has a larger shuttle than an ordinary loom. This increases the quantity of weft in the shuttle and reduces the amount of waste, whilst at the same time reducing the number of changes needed in a given time and the wear and tear on the changing mechanism. On the other hand, the larger shuttle causes greater stresses and more breakages in the warp threads; in addition, it is subject to greater wear and tear, and requires more power to drive it than the smaller shuttle of the ordinary loom. It is open to question whether the shuttles generally used on cop-changing looms are not too large, and whether better results would not be got by using slightly smaller shuttles and weft bobbins. Weft in mule cops can be utilised by putting the cops on special skewers suitable for use in a cop-changer magazine, or the cops can be skewered in the ordinary way for the shuttles of shuttle-changing looms. The skewering increases considerably the time for battery filling in the cop-changer loom, and there is naturally more waste and more liability to loom stoppage for weft breaks caused by bad skewering than when ring-frame bobbins or pirns are used. A good case can be made for rewinding cop weft on to wooden pirns or paper tubes. There are advocates of rewinding ring-spun weft also, but it is fairly certain that it does not pay to do so, and even for cops it is doubtful whether the average yarn can bear the high cost of the rewinding.

Pirn winding for automatic looms is generally done on machines of the high-speed horizontal spindle type, which gives a solid pirn without glazing the yarn. Perhaps the least satisfactory feature of these machines is the constant speed of the spindles, which gives a varying winding speed, due to the varying diameter of the chase on which the yarn is wound. This is corrected, as far as possible, by various tensioning devices, but none of these are entirely satisfactory, and a variable-speed spindle machine has much in its favour. Variable-speed machines have been used to a considerable extent for rewinding weft for ordinary looms and are still used for that purpose, though probably more in the linen industry than for cotton. One of the most modern pirn winders, made by Messrs Hattersley, Ltd., is of the variable-speed spindle type, and gives practically as high a production per spindle as the constant-speed spindle machines. This machine, in common with most variable-speed spindle machines, has vertical spindles, which are hardly so convenient as horizontal ones for putting the pirns on or removing them, and it is also much more difficult to lubricate the spindles satisfactorily, resulting in a lower spindle speed and more difficulty in preventing the lubricant from getting on the yarn.

Although winding machines have been greatly improved since the introduction of the horizontal, high-speed spindle type, the improvements have mainly been in the direction of increasing the output per spindle and not the output per operative, and it is winders' wages that forms the greater part of the cost of rewinding. The work of the winder consists mainly in piecing-up, when replacing cops and when the yarn breaks, and increasing the output per spindle of the machine is accompanied by a reduction in the number of spindles that one operative can keep going. The work is considerably harder than twist winding, as the weft is more delicate than warp and breaks more frequently, the cops or bobbins are comparatively small and run out correspondingly quickly, whilst the threading-up, through the tensioning arrangement and the stop motion which is generally fitted, is rather troublesome. Even when equipped with the Barber knotter, a good winder can only look after about fifteen spindles on, say, 20's counts, these spindles winding about 300 lbs. of yarn per week of 48 hours, whilst the winders' wages would be about 26s. per week, an average of 1.05 pence per lb. of yarn for winders' wages alone. As already stated, this increase in the cost of the yarn will generally be found more than the improved efficiency of the weaving and the reduction of waste warrants, but no hard and fast rule can be laid down, and experiment is practically the only way to decide, in any given case, whether rewinding pays or not. It is chiefly by reducing winders' wages that a reduction of the cost of rewinding can be hoped for. The most promising way of reducing winders' wages is through using larger cops or ring bobbins, to reduce the number of stops for piecing-up. Large ring bobbins are often used in this way in America, where rewinding is more commonly done than in Lancashire, and it is a system well worth considering.

Wooden pirns, when used, are preferably formed with a conical head, as this gives the most satisfactory build of pirn and can be used quite satisfactorily with a side-sweep feeler. They do not hold so much yarn as pirns with parallel shanks, but the shape of the chase in the latter type is liable to vary during the formation of the bottom of the pirn, and occasionally when a feeler is used the latter changes the weft too soon due to irregularity in the chase.

In some of the other branches of the textile industry rewinding of weft is more common than in cotton weaving, and when such is the case there is no difficulty in rewinding for the automatic loom. In linen weaving, for example, weft is commonly reeled into hanks after spinning and wound on to pirns, and here it is easy to adapt the winding for the automatic looms, whether cop changers or shuttle changers. In jute weaving, and coarse linen, on the other hand, solid cop winding on the bare spindle is the normal preparation for the weft, the cops being used in special shuttles into which they fit tightly, the lower half of the shuttle being hollowed out to fit the cop, whilst the top is covered with a flat spring, which can be removed when a new cop is being inserted. The cops are unwound from the inside, which gives very even tension during unwinding. This system is much better adapted to shuttle changing than to cop changing, and with the former type of automatic looms no change is needed in the method of weft preparation. Artificial silk weft, also, on account of the delicate nature of the material and the necessity for having fur-lined shuttles with smooth porcelain or glass eyes, lends itself better to weaving in shuttle-changing than in cop-changing looms. When artificial silk weft is used in cop-changing looms the winding of the pirns requires special care. In American practice, the pirns used are slightly larger in diameter than for cotton and a size shorter. Knots on the weft are liable to cause trouble. A weavers' knot should be used, and the knot should not be placed on the chase but on the outside of the pirn, as otherwise the weft is liable to catch, resulting in a break or in a bright pick, due to over-stressing of the weft. The bobbins or pirns should not be enamelled, as bobbins covered with shellac give the best results.

CHAPTER XIV

THE ORGANISATION OF AN AUTOMATIC LOOM WEAVING SHED

The success of an automatic loom weaving shed, like that of any other, depends on good organisation and efficient management. The most important points are the general lay-out of the shed; the method of driving and the speed of the looms; the organisation of the labour so as to ensure the maximum number of looms per weaver; systematic observation of production and of the cause of excessive loom stoppages; the method of payment and the training of the workers.

In laying out the looms it is necessary that there should be sufficient room for the weavers in the weavers' alley, and room for changing beams and removing cloth, whilst it is desirable that the end passage between pairs of looms should be wide enough to give the weaver ready access from one weavers' alley to the other, and also to permit of the passage of a bogey for conveying full beams to the looms. Wheeling the full beams to the looms in this way, by bogeys, is generally accepted to be the most convenient and cheapest method, except for heavy looms, such as those for sheetings, where an overhead runway system is sometimes preferred, a system which allows of an overhead lifting tackle being used for lifting the heavy beams. A suggested lay-out for a weavers' set of sixteen Northrop looms is shown in fig. 69, this having been found by experience to give the easiest supervision with the least exertion for the weaver.

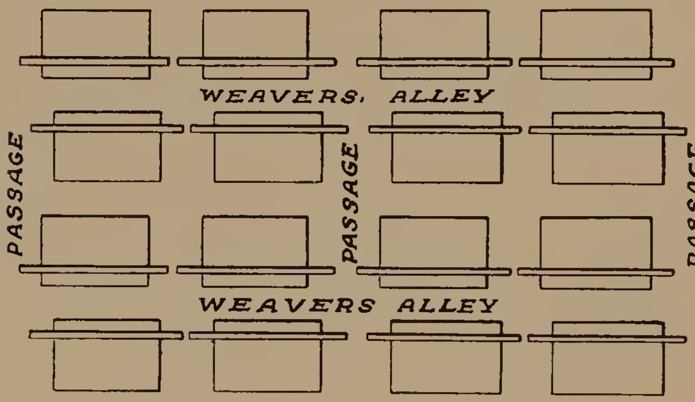

Fig. 69.—Lay-out of Northrop Looms.

The driving of automatic looms is a matter of great importance, for steady speed is essential to give continuous running and to prevent banging-off through loss of speed. The looms are frequently driven by belt, from a line shaft driven by a steam engine in the ordinary way or by an electric motor. But undoubtedly the most satisfactory drive, for looms in a new shed at any rate, is the individual motor drive. The steam-engine drive, through line shaft and belt, may be satisfactory from the point of view of regular speed, this depending mainly on the condition of the engine; very often with old engines the speed is anything but regular, and the loom suffers. But even if the drive is steady, the overhead shafting and belts are by no means satisfactory, obstructing the light and causing damage to the cloth through dirt thrown from the belts and oil drips from the shaft bearings. Moreover, the roof construction must be much heavier to carry the overhead shafting, the number of roof supports must be much greater, and there is more difficulty in keeping the roof water-tight, on account of the shaft vibration, than in a shed where individual motor driving is adopted. The individual motor drive is entirely satisfactory, except that its first cost is high. There can be no doubt, however, that this is balanced by the advantages mentioned, together with the better cloth and increased production. The claims made by the advocates of the electric drive for increased productions of 5 to 10 per cent. over the line-shaft drive are almost certainly too high. It is, indeed, doubtful whether any increased production, or more than 1 or 2 per cent., is realised over that where the line shaft is in first-class condition, but it is probably safe to count on 3 to 5 per cent. increase as compared with the *average* line-shaft drive, whilst 5 to 10 per cent. may be got if the line-shaft drive is in very poor condition.[1] For an old shed, with the shafting in good condition, it will generally pay to drive the looms from the shaft, using either the engine drive, if efficient, or a group motor drive. For a new shed, or one with a line shaft in poor condition, the individual drive is strongly to be recommended. When a line-shaft drive is used, the belt may run on the usual fast and loose pulleys, but undoubtedly for automatic looms a friction clutch is a better drive, on account of the quicker start and stop that can be got. When individual motor driving is used, transmission from the motor to the loom may be by belt or composition rope, by wheel gearing or by chain. For light looms, which run at a fairly high speed, the belt or rope drive is quite satisfactory. The motor is generally arranged to start and stop with the loom, an arrangement which works well for light looms and which increases the efficiency as compared with keeping the motor running throughout the working day. The motor is generally placed on the floor, behind the loom, and as a rule does not increase the floor space occupied by the loom. An endless belt is used, automatically tensioned by means of the spring suspension of the motor. Gear and chain drives are generally to be preferred to belt drives for the heavier types of looms, although many sheeting and other looms are running fairly satisfactorily with belt drives. Gear drives, also, are often advocated for light looms, and have the advantage of ensuring quite regular speed of the loom, so long as the generator speed is constant. Gear driving is considerably higher in first cost than belt driving, and on that account the belt is generally preferred when it is suitable. For heavy, slow-speed looms the speed ratio between motor and loom is generally too great for a satisfactory belt drive. The motors, which are generally alternating current, 200 or 400 volts, 50 cycles, run at 960 revolutions per minute, and a loom running at, say, 120 picks per minute needs a speed reduction of 8 to 1. The only satisfactory way of using a belt drive on such a loom is to combine it with a gear drive, the driven pulley being geared into either the crank shaft or bottom shaft of the loom, so as to permit of a reasonable size of motor driving pulley. For a belt drive of this kind, or for a direct gear drive from the motor to the loom crank shaft, the motor is preferably mounted on the loom framework, so that the driving and driven gear shafts are always in correct alignment. For light looms, driven by gearing, the motor may stop and start with the loom, a slipping friction being introduced either on the motor pinion or crank-shaft wheel to prevent damage if the loom bangs off. For heavier looms it is better to keep the motor running continuously and to start and stop the loom by means of a friction clutch. This gives the quick start, which is very desirable for automatic looms, without using too powerful a motor. The starting of the motor itself takes much more of the starting torque of the motor than the loom does, and with a heavy loom and motor the start-up of the loom is much quicker if the motor is already running at full speed. The clutch is mounted direct on the crank shaft when a direct gear drive is employed, whilst it can be mounted on the pinion shaft when one is used to drive either the crank shaft or the bottom shaft of the loom. A combination of belt and gear drive for a heavy Northrop loom is shown in fig. 70, the clutch being mounted on the pinion shaft, which is connected by wheel gearing to the bottom shaft.

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[1] For an analysis of the advantages of the individual drive, see *Textile Recorder*, September 1926.

The most economical speed for the looms can only be found exactly by experience. Conditions vary so much that no hard and fast rules can be given, although loom makers always supply the approximate speeds recommended for their looms. It will generally be found that a moderate speed is more satisfactory than a very high one, and that the looms will work at considerably higher speeds than the most economical speed. The highest speed possible will rarely be found to be the speed which gives the maximum production from a loom, as the running efficiency will generally be found to be low at the high speed, due to a high number of stoppages for warp and weft breakages, loom repairs, and so on. Nor will the speed which gives the highest production necessarily be the most economical speed, although generally these speeds will not differ greatly The highest production may be got at the expense of excessive depreciation and repairs of the machinery, high expenditure on stores, high tacklers' wages, and even high weavers' wages. The only sure way is to experiment with a reasonable number of looms, running these for considerable periods at different speeds and working out accurately the cost per yard or per piece of cloth, taking into account all factors such as cost of material, weavers' and assistants' wages, depreciation, repairs, and so forth, the best speed being that which yields the greatest amount of profit from the cloth produced.

To carry out tests of this kind is no easy matter, and is more difficult perhaps with individual drive than with line-shaft drive, for the motor speeds cannot be altered as a rule, and if belt driving is used, loom speeds can only be changed by changing the pulley of either the motor or the loom. This is an expensive matter, and generally the manufacturer will rely on his experience or on that of the loom maker in fixing the speeds. It will generally be found that there is a moderately wide range of speed between the limits of which the cost of producing cloth is fairly constant. At the upper limit the loom efficiency will generally be less than at the lower speed, so that the effective picks per

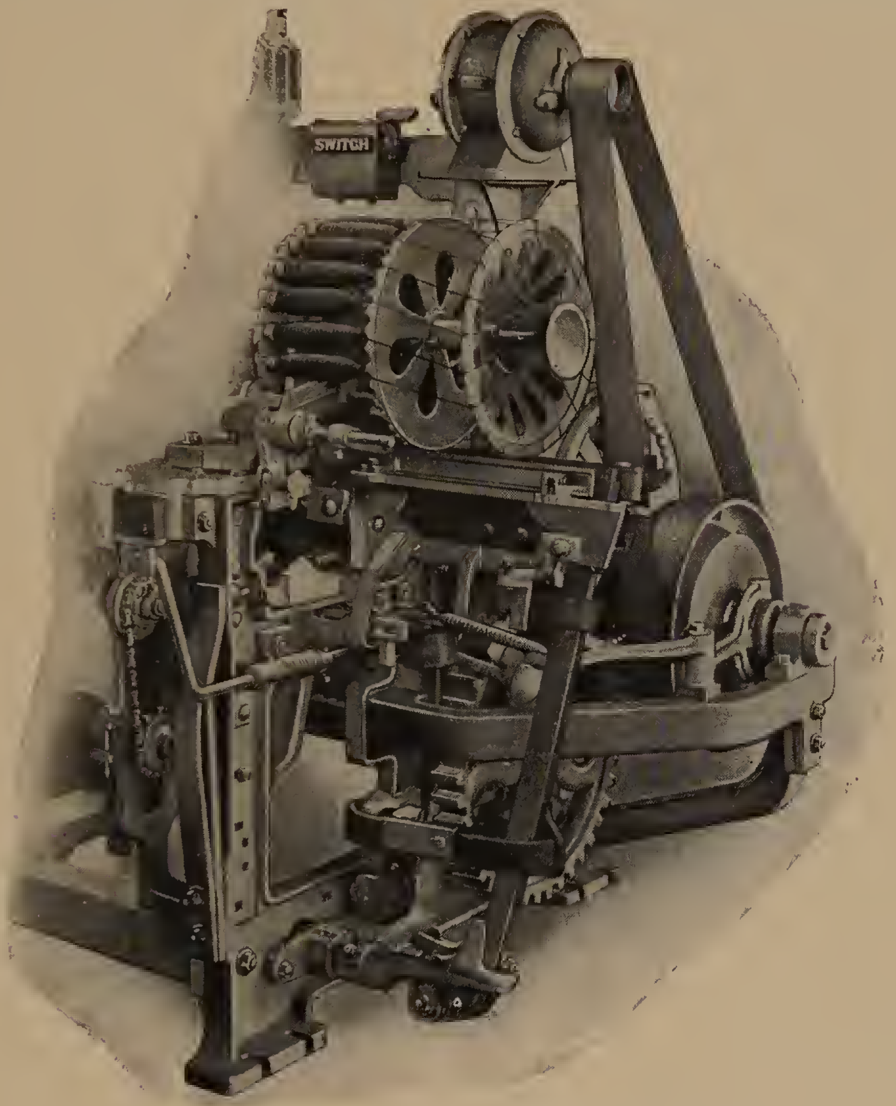

Fig. 70.—Drive for Heavy Northrop Loom.

minute may be very little higher, whilst the number of looms per weaver will be less at the higher speed, and expenditure on loom repairs and stores will be higher. In the absence of more accurate data, it will generally be safest to work near the lower limit rather than the higher. Northrop looms of 40 inches width are recommended by the makers, for example, to run at speeds from 180 to 200 picks per minute, and the former speed will probably be found to be the most satisfactory in the long run.

Good lighting, heating, and humidifying are things which must be provided in any weaving shed that is to be efficient.

One of the most important matters to be decided by the management of an automatic loom weaving shed is the number of looms per weaver. The weaver should look after the maximum possible, this maximum naturally varying with different classes of work. To ensure the maximum number of looms per weaver, it is very desirable that the weaver's work should be confined to the more skilled operations in weaving, whilst many of the minor duties, which normally are part of the weavers' work on ordinary looms, should be done by unskilled and cheap labour. The weaver should not be called on to carry weft to the looms, to remove or pick cloth, to oil or clean the looms, or even to replenish the weft magazine or battery. Bringing weft to the looms and removing cloth to the warehouse, which is fairly heavy work, is best done by a labourer, who ought to look after 300 to 400 looms on grey cloths. Oiling and cleaning of the looms can be done by a youth, who should attend to 70 or 80 plain looms. Every time a warp is finished, the opportunity should be taken to clean the loom, and oil parts which normally are inaccessible. Daily and weekly oiling should also be done systematically, an oiling chart being made out for the guidance of the oilers, the chart showing the parts to be oiled daily throughout the week, some parts requiring attention daily, others every second or third day, whilst some parts require attention only once a week or even when the warp is finished. The replenishment of the weft magazine is often done by the weaver, but it is work that can generally be done satisfactorily by cheap labour, and advantage should be taken of that whenever possible. The number of looms that a battery filler can supply varies considerably, according to conditions, and may be as many as 60. If the capacity of the magazine is known, the approximate time a bobbin or cop lasts, and the time it takes the filler to replenish one magazine, the number of looms per battery filler can easily be calculated. The two last items can readily be timed on different sorts. Thus, if n is the number of bobbins or shuttles in the magazine; t the time each bobbin or shuttle will run; and y the time the filler takes to fill one battery; then the number of looms a battery filler can attend to will be $\frac{nt}{y}$. For example, if a Northrop loom battery holds 24 bobbins, which each will run 5 minutes on the average, whilst to fill a battery takes 2 minutes with bobbins and 4 minutes with cops, the number of looms per battery filler, using bobbins in the magazine, will be $\frac{24\times5}{2}=60$, and with cops $\frac{24\times5}{4}=30$. If the times of 2 minutes and 4 minutes are the exact times taken, and they should be about correct, it will be necessary to reduce the calculated number of looms by about 25 per cent., as the worker should not be expected to be fully employed for more than 40 to 50 minutes per hour. The numbers then would be $0{\cdot}75\times60=45$ with bobbins, and say 24 with cops. Or again, if a shuttle-changing loom has a magazine capacity of 10 shuttles, each of which will run for 5 minutes, whilst a battery filler can fill the magazine in 2 minutes, then the number of looms per battery filler will be $\frac{10\times5}{2}\times0{\cdot}75$, say 20 looms. In a somewhat similar way the number of looms per weaver can be calculated, but the data on which the calculations are based are not quite so easy to collect, although of very great importance. The working efficiency of the looms ought to be known. It can readily be calculated from the readings of the pick indicator—which should be fitted to every automatic loom—and from the known speed of the loom. Any loom which shows a low efficiency should be tested over as long a period as practicable, and the cause of the inefficiency found, when it will generally be possible to remove it. The causes of loom stoppages, together with the approximate duration of each stop, should be carefully analysed, as in that way many of these causes may be removed or minimised, and the loom efficiency improved. Records of the tests should be kept and are then available for comparing with the results from any loom which is showing a low efficiency. The chief causes of stoppages are: (1) warp breakages and slack warp ends; (2) weft breakages, weft running out, or weft failing to thread up in the shuttle eye in cop-changing looms; (3) shuttle-changing trouble in shuttle-changer looms; (4) bang-off, due to faulty adjustment of the loom or irregular drive.

Examples of suitable test sheets for recording analyses of loom stoppages, loom efficiency, etc., are given in Appendix II, which also gives the calculations for the correct number of looms per weaver. The weaver's work consists in attending to the loom when it stops, in general supervision, and, it may be, removing cloth, whilst, in addition, the weaver may have to fill the batteries of the looms. The time spent on loom stoppages naturally depends on the number of loom stops per hour and also on the average duration of each stop. These factors can only be determined, with any degree of accuracy, by actual tests, as they will be found to vary very considerably with different conditions. With well-prepared cotton warp and weft the average number of stops per loom per hour should not exceed between one and two, with the average duration of stop about 1 minute. The time spent in general supervision also varies, but will generally average about 1 minute per loom per hour when the weaver removes cloth from the looms, and about half of that time when cloth removal is done by other labour. The time spent in battery filling, whether done by the weaver or by special labour, should be about 2 minutes with bobbins to

4 minutes with cops for a Northrop or other magazine with 24-bobbin capacity, whilst to fill a 10- or 12-shuttle magazine should not take more than 2 minutes, or about $1\frac{1}{2}$ minutes if the weft is rewound on pirns. At first sight it might appear that the greater the capacity of the magazine the better, but this is only true to a limited extent, there being very little difference after about 10- or 12-bobbin or shuttle capacity. The time taken to fill the magazine is almost directly proportional to the number of bobbins or shuttles it holds, since over about 10- or 12-bobbin capacity the time spent in going from one loom to the next is negligible, in comparison with the time spent in filling, and if the magazine has a large capacity, the longer time it will run is balanced by the reduced number of magazines that the filler can attend to per hour. A large capacity is probably more desirable when the weaver has to do the work, as she cannot attend to the filling of the magazines quite so systematically as a battery filler whose sole occupation is that work. For the same reasons the weaver cannot be expected to do the battery filling at quite so high a rate of speed as the special battery filler can, as the weaver may be called away in the middle of filling a magazine to attend to a loom which has stopped, perhaps at the far end of her group of looms.

If the times taken by these various operations have been found by tests, it is a comparatively easy matter to work out the number of looms that a weaver can be expected to attend to, either on the lines given in the Northrop tables in Appendix II, or in the following way:—

If N is the number of looms per weaver, S the average number of stoppages per loom per hour, and T minutes the average duration of a stop,

Then NST is the time spent per hour by the weaver on loom stoppages. Also, if the time for general supervision and removing cloth is taken at 1 minute per loom per hour, the time spent on this work per hour by the weaver is a further N minutes.

Allowing, say, 45 working minutes to the hour, then, without battery filling,

$$\mathrm{NST}+\mathrm{N}=45 \quad \text{or} \quad \mathrm{N}=\frac{45}{1+\mathrm{ST}} \quad . \quad . \quad . \quad (1)$$

If the weaver has to do battery filling, then, using the same letters as above for this work, n being the number of bobbins or shuttles in the magazine, t the time each bobbin will run, and y the time taken to fill a magazine, then the time spent per loom per hour will be $\frac{60y}{nt}$, since y minutes have to be spent on each loom magazine every $\frac{nt}{60}$ hours.

The total time spent in battery filling per hour will therefore be $\mathrm{N}\left(\frac{60y}{nt}\right)$, and we have

$$\mathrm{N}\left(\mathrm{ST}+1+\frac{60y}{nt}\right)=45 \text{ minutes per hour} \quad . \quad . \quad . \quad (2)$$

For example, taking the number of stops $S=1\cdot 5$ per loom per hour, and the average time $T=1$ minute per stop, then if the weaver does not have to fill the magazine,

$$N=\frac{45}{1+1\cdot 5} \text{ from (1), or } N=\frac{45}{2\cdot 5}=18 \text{ looms per weaver.}$$

If the weaver has to fill, say, magazines of 12-shuttle capacity, taking 2 minutes per magazine, and the shuttles lasting 6 minutes each, then the time spent in this work per loom per hour $=\frac{60\times 2}{12\times 6}=1\frac{2}{3}$ minutes, and $N(1\cdot 5+1+1\frac{2}{3})=45$, or $N=11$ looms approximately.

When mule-cop weft is used the skewering must be done at the loom for shuttle-changing automatics. But for cop-changing looms the cops are preferably skewered in the weft store by special labour, paid at a higher rate than the battery fillers, if the latter are employed at the looms.

In automatic weaving sheds the payment of the weavers is usually based on the number of picks put in, as recorded by the pick counters of the looms. The rate of payment naturally varies with different kinds, qualities, and widths of cloth; and some examples of price lists used for weavers on Northrop looms are given in Appendix III. This method of payment by pick counter, instead of by the piece, has many advantages. The weaver has every encouragement to keep all of her looms running all the time, if possible, and is not tempted to concentrate on one or two, in order to get certain pieces off before the end of the week. Nor is there any temptation to the weaver to tamper with the let-off weights, if these are used, in order to get the warp weaving down somewhat faster.

Battery fillers and labourers are paid a fixed wage, which is practically equivalent to piece-work payment, since each worker has to supply a given number of looms. The overlookers are generally paid a fixed wage, and in addition a bonus is very often added, varying according to the average efficiency of the weavers for whose looms they are responsible. Sometimes the bonus starts at 80 to 85 per cent. efficiency, the rate increasing above 90 per cent. for ordinary cotton goods. In other cases a small bonus is paid for every 1 per cent. up to 60 or 70 per cent., with a considerable increase in the rate of bonus above 60 or 70 per cent. The efficiency at which the bonus begins to operate naturally varies in different branches of the industry. The value would commonly be lower, for example, in linen and woollen weaving than in cotton, as it is more difficult to keep the looms running in the former than in the last-named industry.

If possible, young workers should be selected for work on automatic looms, as they prove more adaptable than old weavers who have been accustomed to ordinary looms. This applies perhaps with even greater force to the tacklers than to the weavers, for it is naturally difficult for an old tackler, whose experience has all been with ordinary looms, to adapt himself to the changed conditions with automatic looms, if indeed he has sufficient mechanical knowledge to enable him to handle the more intricate machinery. Probably the most satisfactory method is for the manufacturer to send one or two of his most promising young tacklers for a course of training at the loom makers' works, where they can have the mechanism of the looms thoroughly explained and be given some experience in the adjusting of the various parts and the carrying out of repairs. Such men could then be used, when required, to give instruction to other tacklers. Certainly the latter should receive some definite training in mechanical fitting, and if the same man is required to do the gaiting-up of the warps, etc., as he almost invariably is, he must also have a good knowledge of cloth structure.

Repair work on automatic looms, as indeed on others, must be carefully done. When spare parts are required these should always be got from the loom makers, as the quality will almost invariably be better than if the parts are obtained elsewhere. Also, it often happens that some improvement may have been made by the loom maker on the particular part required, and the manufacturer can get the benefit of this at the same time that the repairs are carried out. It is very undesirable that the looms should be altered or new parts added except through the loom maker, as this may lead to trouble if it is desired to change the looms over to deal with some other kind of cloth, for it may be found that the necessary parts for the change cannot be fitted, due to the alterations that have been made to the looms.

An interesting study is afforded of the effect of the quality of the labour on the number of workers required, by some statistics published (1928) by the Lancashire Cotton Yarn Association on cotton spinning in India. An example is given there of the labour employed on 100 Northrop automatic looms, which require 17 weavers, 8 magazine fillers, 4 weavers' helpers, 4 oilers, and 3 others, making a total of 36.

In another mill, of 1025 Northrop looms, the labour includes 163 weavers on 6 looms, 11 weavers on 4 looms, one weaver on 3 looms, 43 jobbers, 42 sweepers, fitters, clerks, weft-room helpers, and sundries. The labour required in Lancashire for this number of looms would probably work out at about 50 weavers, 20 battery fillers, 14 tacklers, 14 oilers, and 4 labourers. The wages of the weavers in India are given at 15s. 9d. per week, and, taking the others in proportion, the total wages bill works out at about £245 per week, which is just about the same, or a little higher, than the labour cost in Lancashire.

CHAPTER XV

AUTOMATIC LOOMS IN THE COTTON INDUSTRY

Automatic looms have been adopted to a greater extent in the cotton trade than in any other. The material itself is more suitable than most others for the conditions met with in automatic weaving, being generally neither too coarse nor too delicate, whilst it is reasonably strong and extensible, and it stands the rubbing and chafing of healds, reeds, and warp stop motions without excessive breakages. Many of the cloths, also, are suitable for large scale production, and the majority can be woven with a single box at one side of the loom, which may be considered as essential with automatic looms. But, although there is now much cloth woven on automatic looms, they are by no means universally used, even for the commoner types of cotton cloths. In Lancashire, for example, with a few exceptions, manufacturers continue to use ordinary type looms, whereas in America the majority of the looms are automatic, chiefly of the Northrop type, and in Japan shuttle-changing automatic looms are common. The attitude of Lancashire is due to many causes, partly to the nature of her trade, which is largely, though by no means entirely, in the better classes of cotton goods. Another factor is the way in which the trade is organised, the manufacturer generally buying his yarn from a spinning mill, whereas automatic looms show to best advantage in large combined mills where the benefit of weft on ring bobbins can be realised. There have also been financial difficulties, especially since the War, which have prevented any great outlay on new equipment. The attitude of the workers and their trade unions has not usually been very friendly to the introduction of automatic machinery, whilst the Lancashire manufacturers themselves have not, in general, been convinced that the automatic loom would be a paying proposition. There can be very little doubt, however, that Lancashire will have to adopt automatic looms in the near future if she is to continue to compete in the commoner types of cloth, whilst for many of the finer and more complex cloths there are advantages in automatic weaving that make it almost certain that that system will be adopted for most cotton fabrics.

Before the manufacturer can decide on the extent of the advantages he is likely to derive by using automatic looms, he must carefully consider the conditions under which his work is carried out, and preferably should make a thorough study of the working of his existing looms, to see whether the conditions are suitable for the automatic system. Careful tests of the number and duration of stoppages and their causes will enable him to estimate fairly accurately the number of automatic looms per weaver that he can reasonably expect to run, and, knowing the cost of the new looms, he can work out fairly closely a comparison between the two systems. Warp and weft breaks are generally the most frequent causes of stoppages, and these will generally be rather higher with automatic looms than with ordinary ones, due to the action of the warp stop, and of the cop changing if that system is adopted.

The following comparisons between ordinary looms and automatics on grey goods are worked out as accurately as possible, to give some idea of the nature of the saving that can be anticipated by introducing automatic looms under the conditions prevailing in Lancashire.

Cost Comparison between Ordinary and Automatic Looms

Shed of 1000 looms, 36 to 40 inches reed space, weaving grey plains, twills, etc.

The production per loom is taken to be the same for the automatic as for the ordinary loom, the lower speed of the former being balanced by the higher running efficiency. Generally speaking, a slightly higher production can be reckoned on from the automatic loom, weaving the same cloth as the ordinary loom, but throughout this comparison the conditions have been taken, if anything, to favour the ordinary loom.

CAPITAL COSTS. *Ordinary Looms.*—1000 looms at £20=£20,000; allow 5 per cent. for interest and 5 per cent. depreciation per annum. Annual cost=£2000.

Automatic Looms.—1000 looms at £60=£60,000; allow 5 per cent. for interest and 6 per cent. for depreciation per annum. Annual cost=£6600.

Weft-winding Machines.—Taking 1 spindle per loom, number of spindles required=1000; say, 50 20-spindle machines at £100=£5000; allow 5 per cent. for interest and 8 per cent. for depreciation per annum. Annual cost=£650.

LABOUR. *Weavers' wages,* for ordinary looms at 4 looms per weaver, would average about £30,000 per annum.

For automatic looms, using bobbin weft, at 16 looms per weaver, but allowing the weavers $12\frac{1}{2}$ per cent. higher wages than on ordinary looms, weavers' wages would be £7500+$12\frac{1}{2}$ per cent.=£8450 per annum.

For automatic looms, using cop weft, at 12 looms per weaver (the lower number as compared with bobbin weft being due to more stoppages through weft breaks, etc.), weavers' wages would be £10,000+$12\frac{1}{2}$ per cent.=£11,250 per annum.

Overlookers' Wages.—For ordinary looms at, say, 1s. 7d. per £1 of weavers' wages:

$$30{,}000 \times \frac{19}{240} = £2380 \text{ per annum.}$$

For automatic looms, allowing fewer looms per overlooker in the proportion of 75 to 100 and 10 per cent. higher wages than on ordinary looms:

$$2380 \times \frac{100}{75} \times \frac{110}{100} = £3500 \text{ per annum.}$$

Battery Fillers' Wages.—With bobbin weft, at 50 looms per operative and £1 per week each, wages = 20 × 1 × 50 (weeks per annum) = £1000 per annum.

With cop weft, at 25 looms per operative, but taking the weekly wage at 30s. because of the greater skill needed for cop skewering than for battery filling, wages = £3000 per annum.

Labourers, for carrying weft and cloth, 3 at 50s. per week, wages = £375 per annum.

Oilers and Cleaners.—14 operatives at £1 per week each, wages = £700 per annum.

Winding weft from cops to pirns, say, 20,000 lbs. of weft per week, at $1\frac{1}{2}$d. per lb. for winding. Cost of winding $= \frac{20,000 \times 1 \cdot 5}{240} \times 50 = £6250.$

Inspecting and Picking Cloth.—Allow £1000 per annum for ordinary looms and £2000 per annum for automatic looms.

Annual Cost Summary

	Ordinary Looms (4 Looms per Weaver).	Automatic Looms.		
		Ring Bobbin Weft (16 Looms per Weaver).	Cop Weft (12 Looms per Weaver).	Rewound Cop Weft (16 Looms per Weaver).
Annual capital cost—	£	£	£	£
Looms . .	2,000	6,600	6,600	6,600
Winding machines	. .	. .	. .	650
Weavers' wages .	30,000	8,450	11,250	8,450
Overlookers' wages .	2,380	3,500	3,500	3,500
Battery fillers' wages	. .	1,000	3,000	1,000
Labourers' ,,	. .	375	375	375
Oilers' ,,	. .	700	700	700
Winding weft . .	. .	. .	. .	6,250
Inspecting and picking cloth . .	1,000	2,000	2,000	2,000
Total annual cost	£35,380	£22,625	£27,425	£29,525

On an average weekly production of 220 yards of cloth per loom this represents a saving in favour of automatic weaving varying from about 2s. 4d. to 1s. 1d. per piece of 100 yards. The cost of warp preparation would probably be slightly higher for the automatic than for the ordinary loom, but, on the other hand, the number of looms per weaver is frequently higher with automatic looms than has been assumed here. It will be seen that the cost of rewinding is high, but it must be remembered that rewinding can be counted on to reduce the waste of weft considerably, an item which has not been considered in the above table. An ordinary allowance for waste of weft for ordinary looms is 5 per cent., and an automatic loom, using ring bobbin or cop weft, should not exceed this if the feeler motion is accurately set. Rewinding of the weft ought to reduce the waste at the loom to 1 per cent. or less, but it must be remembered that there is a certain amount of waste made at the winding machine. A liberal estimate would be that rewinding saves 4 per cent. of the weft, leaving 1 per cent. of waste. The looms in the above shed would use about 1,000,000 lbs. of weft per annum, costing, say, 15 pence per lb., and 4 per cent. of the cost of the weft works out at about £2500 per annum, making no allowance for th value of the waste. Crediting the system using rewound weft with this £25 per annum would bring the annual cost of that system down to approximat the same figure as that for the system using cop weft direct in the shuttle.

Another comparison, from figures supplied by the British Northrop Loom Co., is given below, based on an overlooker's set of 50 looms, weaving cotton sheetings up to 85 inches wide, with 50 picks per inch, under the following conditions for a 48-hour week:—

	Ordinary Loom.	Northrop Loom.
Production—		
Speed of loom	115 picks per minute	115 picks per minute.
Efficiency	78 per cent.	90 per cent.
Effective picks per minute	88	103
Looms per weaver	2	8
Production per loom per week	142 yards	165 yards.
Production per weaver per week	284 ,,	1320 ,,
Costs—		
Weaver's wages (say)	£2 10 0	£3 0 0
Number of weavers (50 looms)	25	6
Total weavers' wages	£62 10 0	£18 0 0
Overlooker's wages (say)	£4 0 0	£4 10 0
Cloth inspecting, cleaning, oiling, etc.	£1 15 0	£7 15 0
Total wages per week	£68 5 0	£30 5 0
Wages per loom per week	£1 5 0	£0 7 6

	Ordinary Loom.	Northrop Loom.
Expenditure—		
Price of loom (equipped) . . .	£68	£187
Capital outlay (50 looms) . . .	£3900	£9350
Depreciation at 5 per cent. per annum	£195	£467
Wages per week	£68 5 0	£30 5 0
Depreciation per week . . .	£3 8 9	£9 7 6
Total cost per week	£71 13 9	£39 12 6
Saving per week	..	£32 0 0
Summary—		
Production per week . . .	7100 yards	8250 yards.
Cost per week	£71	£39
Cost of production per piece of 60 yards	12s.	6s.
Extra capital employed . . .	..	£5950
Saving on 50 looms per annum . .	..	£1600
Interest on extra capital employed .	..	27 per cent.
(plus profit on increased production of	..	57,500 yards per annum).

The question as to what is the best type of automatic loom for the cotton trade is one which admits of no general answer and one on which experts differ; indeed, many practical men, in Lancashire at least, will argue that for the bulk of cotton goods no automatic loom is satisfactory. As already stated, the bulk of cotton goods in America are manufactured on automatic looms, mainly of the cop-changing type, although many shuttle changers are also in use, the latter type also being largely used in Japan, whilst on the continent of Europe cop-changing looms are most common. In Lancashire the Northrop loom is the automatic loom that has been tried chiefly, but the numbers in use there are comparatively small considering the time that the looms have been available, whilst it will be found that most of the firms using Northrop looms still retain a large number of looms of the ordinary Lancashire type. Since the War a considerable number of cop-changing attachments, mainly of the Whittaker type, have been introduced; but here again their use will be found, generally, to be confined to the coarser cloths, the ordinary Lancashire loom being preferred, even in the same shed, for weaving the finer materials. Shuttle-changing looms are very little used, a fact which is no doubt largely due to one of the best shuttle changers, the Stafford loom, not having been available in Lancashire. This restriction has now been removed, and in the form of the Vickers-Stafford loom Lancashire will have the opportunity of trying this type. It must be admitted that the Hattersley shuttle changer, which works on the same general principles as the Stafford, has been available, but there are certain differences in construction, as noted in the chapters on these looms, which may make all the difference between success and failure.

There can be no question, from the experience of America, Lancashire, and elsewhere, that cop-changing looms, such as the Northrop, are eminently well suited for the commoner sorts of cotton cloth, particularly when these cloths do not need to be "pick found," the change taking place through the action of the weft fork. The use of the feeler is often preferable, even for such cloths, as change by the weft-fork means a broken pick at practically every new bobbin, which is rather a different thing from the occasional broken or double pick which occurs in cloth woven on the ordinary loom without pick finding. The feeler motion on the automatic loom should prevent broken picks except when the weft breaks and the loom stops by the action of the weft fork, although if the weft cutter is not in perfect order there may be occasional double picks when the weft change occurs. It is mainly this difficulty, caused as explained in the chapter on the Northrop loom, of getting cloth absolutely free from double picks at the change, which has restricted the use of the cop-changing loom for pick-found cloth. If the feeler is working perfectly, it ensures a proper weft change with a minimum of waste. Even if the feeler is somewhat erratic, and occasionally allows the weft to run out, that is not very serious, as the loom automatically stops, and the weaver, before restarting, can see in the usual way that the pick is correct. But if the least defect develops in the weft cutter and holder, it is practically certain that sooner or later the shuttle will draw in an old weft end together with the new weft and cause a fault. It is difficult to keep the weft cutters working efficiently enough to guarantee no faults of this kind throughout the piece. Other points are often brought up against the automatic loom, such as that it will not weave so good and well-covered cloth as the ordinary loom. Whatever truth there may be in such assertions, and it is very doubtful whether, on the whole, there is any, such difficulties as cause this can be removed; but the trouble with the weft will not be so easy to eliminate entirely. The shuttle-changing loom, for reasons already given, does not give the same trouble with the weft, and hence for pick-found cloths it has a very great advantage over the cop changer. Partly because of its better suitability for pick-found cloths, and also because of its more gentle treatment of the weft at transfer, the shuttle-changing loom is preferable to the cop changer for delicate cotton fabrics. Also, for the very coarsest cotton fabrics, which are generally woven with weft in solid cop form, the shuttle changer enables a suitable shuttle to be used and consequently is to be preferred for these fabrics. For cloths requiring two shuttles, for check work at any rate, cop changing is a much easier method than shuttle changing owing to the difficulties of working a two- or four-cell magazine for shuttles. The two-, four-, or even six-colour cop-changing loom has been developed by several firms, and can be considered as a practical loom, although it suffers from the difficulty already discussed of satisfactory cutting of the weft, and, moreover, it is limited to cloths in which single picks are not required. This leaves, however, the bulk of checked and coloured cotton fabrics as suitable for automatic weaving.

The advantages claimed for an automatic attachment as compared with a complete automatic loom have already been considered, the chief generally being that of low capital cost. The following comparison, however, between Northrop looms and looms with Whittaker attachments shows that there is not so great a difference in cost as is often supposed. Looms with the attachment are often run without automatic let-off, sometimes for the sake of cheapness, often because the friction let-off is preferred; but this throws extra work and responsibility on the weaver and cannot be considered entirely satisfactory, whilst it is bound to reduce the number of looms that the weaver can supervise.

Cost Comparison

	Whittaker Motion.	Northrop Loom.
41-inch reed-space Lancashire loom	£20 0 0	36-inch size T model Northrop loom, complete with all equipment.
Whittaker attachment, fitted .	15 0 0	
Warp stop motion, complete . .	7 0 0	
Bobbins, shuttle, strapping, etc. .	2 0 0	
Automatic let-off motion . .	5 0 0	
Total .	£49 0 0	£56 0 0

The motion can, of course, be fitted to an old loom, but it is not generally advisable to do so unless the loom is in very good condition.

CHAPTER XVI

AUTOMATIC LOOMS IN INDUSTRIES OTHER THAN COTTON

ALTHOUGH it is in the cotton industry that automatic weaving has made most progress, the system is used to a considerable extent for woollen and worsted, linen and jute, and even for silk and artificial silk. Woollen and worsted cloths are, generally speaking, more expensive than cotton fabrics, and in the majority of cases broken picks are not permissible. Shuttle-changing looms would thus appear to be the most suitable, and as in many of the cloths weft mixing is required, a suitable two-shuttle motion must be used. The use of automatic looms in this industry is considerably limited by the number of fabrics which require single picks, for which the automatic loom is not suitable.

In linen and jute weaving the conditions seem generally favourable for the use of automatic looms. Much of the cloth woven from these fibres is simple in structure, most of it is woven grey, and often the pick need not be found. In the linen centres of the British Isles, however, automatic weaving has not been introduced to any marked extent, and this is largely due to the nature of the fibre itself. Linen stretches much less than cotton before breakage, and, generally speaking, more trouble is experienced in weaving it, great care having to be taken with the shedding and let-off motions to keep the load on the warp threads as regular as possible. Even then the number of warp breakages is higher than with cotton, a fact which reduces the efficiency of the looms and lowers the number of looms per weaver. The shuttle of the automatic loom, of the cop-changing type at least, is generally larger than the ordinary linen shuttle, and this throws great load on the warp, increasing the rate of breakage of the warp threads and reducing to some extent the quality of the cloth. It is quite likely that the shuttle-changing type, using the ordinary size of linen shuttles, and adapted to the special requirements of the fibre generally, will meet with more success than the cop-changing loom. The weft in this industry is generally rewound on to wooden pirns, and there is therefore not the same difficulty of the extra cost of weft preparation that is generally met with in the cotton trade.

The conditions in the jute-weaving industry again favour shuttle-changing looms rather than cop changers, and the new looms that are being developed for the jute industry are generally of the former type. The material is coarse, and the common practice is to use the weft in the form of solid cops, wound on the bare spindle, and used in special shuttles, in which the cops are enclosed. It is not likely that this system, which gives very good weaving results and low waste, will be displaced by a system using pirns, and hence the preference for the shuttle-changing type. The cloths woven are generally plain or simple twills, and a satisfactory weft replenisher ought to be widely employed.

Silk and artificial silk fabrics are woven to a considerable extent by automatic machinery. On the continent of Europe and in America silk automatic looms of the cop-changing type are made by several firms. Silk, although generally very fine, is strong, and both warp and weft can stand the strain and rubbing caused by stop-motion wires and threading up in the shuttle. The looms are often fitted with a box motion for either two or four shuttles, since weft mixing has frequently to be carried out, and often check weaving also. Artificial silk, which is now largely used as warp and even more as weft, has peculiarities which must be considered when this material is used in automatic looms. The material is smooth and slippery, which makes it very liable to slough off the pirns when in the shuttle and in the magazine of a cop-changing loom; it does not stand much friction before it frays and causes trouble, whilst it must not be over-stressed as it takes a permanent stretch and changes in appearance, showing up as a bright pick or end. Moreover, the material is very susceptible to atmospheric changes, being weakened very much by damp, and consequently great care must be taken to keep the atmosphere as dry as possible. These characteristics of the material render it, on the whole, more suitable for weaving in shuttle-changing automatic looms than in cop changers, although the latter are used to some extent, particularly for union fabrics with artificial silk warp and cotton weft. When artificial silk is used as warp, great care must be exercised to prevent any more rubbing than absolutely necessary. Friction at the back rest is either eliminated entirely by lifting the beam to the level of the healds and using a friction let-off, or, if the automatic let-off is used, the back rest should be free to turn easily and should be as light as possible. The drop wires at the warp stop motion must be smooth and should have an occasional dusting with French chalk to reduce friction. The reed should preferably be made from smooth, oval section wire to reduce rubbing, whilst the race board should be covered with swansdown to prevent the shuttle from rubbing the warp during its passage. Special take-up rollers are preferable, such as the semi-positive type where the cloth roller is driven by gearing through a slipping friction, so as to reduce the frictional driving force needed at the surface of the take-up or sand roller, which, for artificial silk, is preferably covered with emery cloth. The shed formed should be as shallow as possible consistent with leaving a clear passage for the shuttle. This is more easily done with the shuttle changer, which can use a normal artificial silk shuttle, than with the cop changer. There is no very great difficulty in using artificial silk weft in a shuttle-changing loom, except that great care must be exercised to keep the shuttle boxes clean and smooth, for artificial silk readily clings to the slightest roughness in the box, causing a loop of weft to be left behind when the shuttle leaves, a loop that is almost invariably drawn into the cloth one or two picks later. Lining of the front of the boxes with swansdown may sometimes have to be resorted to, in order to prevent this fault. In the cop-changing loom it is impossible to prevent a certain amount of friction on the weft at the shuttle eye during threading up, and the eye itself is not quite so satisfactory as the eye used in the ordinary type of shuttle. It is also more difficult to get a satisfactory shuttle lining that will prevent sloughing-off of the weft, especially since the position of the bobbin in the shuttle is liable to vary slightly. In American practice with Northrop looms on artificial silk, a slightly larger bobbin is commonly used than for cotton. A tape drag is applied to the pirn noses when in the magazine, to prevent sloughing of the yarn, due to vibration, and a special thread cutter is used which cuts the thread at the shuttle eye. Since the weft is liable to break somewhat frequently, it is desirable to fit a double weft fork, one fork at each side of the loom, to prevent, as far as possible, defects due to broken picks.

APPENDIX I

COST OF GREY WARP PREPARATION

Comparison of Grey Winding and Warping Systems

The figures given below, whilst worked out as carefully as possible, and obtained from as accurate sources of information as possible, must be taken as approximate only.

Number of looms in shed=1133.

Weight of twist yarn required=24,760 lbs. per week of 48 hours. Counts from 10s. to 60s.

System No. 1.—Ordinary Lancashire system of upright-spindle winding and beam warping.

Number of winding spindles required, 1775.	Capital cost of machines	=£1080
,, ,, beaming frames ,, 11.	,, ,, ,,	550
	Total	£1630

Labour—Winders, 45 operatives at 33s. per week	=£75	0	0
Warpers, 11 ,, ,, 35s. ,,	19	0	0
	£94	0	0 per week

=94×50=£4700 per annum.

System No. 2.—American slow-speed system, using the same winding as in No. 1, and the same type of beaming frames, but with several beaming frames per operative, with help for creeling.

Number of winding spindles, 1775.	Capital cost	=£1080
Number of beaming frames, 14 (speed 60 yards per minute, efficiency 60 per cent.).	Capital cost	= 700
	Total	£1780

Labour—Winders, 45 operatives . . .		£75	0	0
Warpers, 2 with 4 machines 2 with 3 machines	at 40s. .	8	0	0
Creelers, 3 . .	at 20s. .	3	0	0
		£86	0	0 per week

=£4300 per annum.

System No. 2a.—Similar system to No. 2, but using American type winding and warping machines, which differ slightly from the English type. Also with the winders using automatic knotters, which is assumed to increase the number of spindles per winder from 40 to 50.

Capital cost of machinery £2590

Labour—Winders, 36 at 33s. per week . .	£60	0	0
Beamers and creelers as in No. 2 . .	11	0	0
	£71	0	0 per week

=£3550 per annum.

System No. 3.—High-speed warping system, warping from stationary bottle-shaped bobbins.

Number of winding spindles, 1800. Capital cost	=£2050, including cost of knotters.
,, ,, beaming frames (at 200 to 300 yards per minute), 4. Capital cost	=£1000
Total	£3050

Labour—Winders, 36 at 33s. per week .	£60	0	0
Beaming, 4 at 40s. ,, .	8	0	0
1 at 20s. ,, .	1	0	0
	£69	0	0 per week

=£3450 per annum.

System No. 3a.—High-speed warping system, warping from cones wound on the Universal No. 60 G.F. Cone Winder, fitted with clearers, stop motion, and hand control for a slow start.

An increase in production is claimed for this machine, as compared with the upright-spindle machine, amounting to about 36 lbs. of 30s. per spindle per week, against about 11 lbs., whilst the increased production per operative is 880 lbs. of 30s. per week, against 550 lbs. These figures for the upright-spindle winder are rather low and are based on the low spindle speed of 500 revolutions per minute. A common production on this count would be about 14 lbs. per spindle per week and about 700 lbs. per operative.

Number of winding spindles, 690. Capital cost	=£5200, including cost of knotters.
,, ,, beaming frames, 4. ,, ,,	= 1080
Total	£6280

Labour—Winding, 28 at 33s. per week .	£46	0	0
Warping, 2 at 40s. ,, .	4	0	0
Creeling, 2 at 20s. ,, .	2	0	0
	£52	0	0 per week

=£2600 per annum.

System No. 4.—Barber-Colman system, using automatic winding machine and high speed warper with electrical stop motion.

Number of winding machines, 4 units, each of capacity 8000 lbs. per week . . . .
,, ,, warping machines, 3 machines, capacity 10,000 lbs. per week each . . .
} Capital cost=£10,000.

Labour—8 winders	at 25s. per week . .	£10	0	0
3 warpers	at 40s. ,, . .	6	0	0
2 creelers	at 50s. ,, . .	5	0	0
1 mechanic	at 80s. ,, . .	4	0	0
		£25	0	0 per week
				=£1250 per annum.

Cost Summary

	Capital Cost.	Capital Charges per annum (11 per cent. on Capital).	Wages per annum.	Total per annum.	Cost per lb. Yarn.
	£	£	£	£	Pence.
No. 1 System	1,630	180	4,700	4,880	0·945
,, 2 ,,	1,780	196	4,300	4,496	0·87
,, 2*a* ,,	2,590	285	3,550	3,835	0·745
,, 3 ,,	3,050	336	3,450	3,786	0·73
,, 3*a* ,,	6,280	690	2,600	3,290	0·635
,, 4 ,,	10,000	1,100	1,250	2,350	0·455

Capital charges assumed are: Interest, 5 per cent.; depreciation and repairs, 4 per cent.; rates, etc., 2 per cent. Messrs Barber Colman give 3 per cent. for depreciation, but that seems to be too low. Floor space is somewhat less for the high-speed warping systems and for the Barber-Colman system, but this is partly balanced in the last system by the increased cost of power.

APPENDIX II

TEST SHEETS AND ANALYSIS GIVEN BY KIND PERMISSION OF MESSRS THE BRITISH NORTHROP LOOM CO., LTD.

RECORD AND ANALYSIS OF LOOM STOPPAGES ON A TWO HOURS' TEST

Firm's Name.......................

Address.......................

Date...........

Temperature of Shed................

Weather..........................

RECORD.		Time—in Quarter Hours.								Total Stops per Loom (in 2 hours).	ANALYSIS.		Analysed Stoppages per Loom per Hour.
Loom Numbers.	Loom Sizes.	STOPPAGES.—Recorded by their Respective Numbers.									Cause of Stoppages.	Totals.	
											1. Warp Break 2. Slack End 3. Weft Break 4. Mis-thread 5. Weft Run Out 6. Bang Off 7. 8. 9. 10.		1 2. 3. 4. 5. 6. 7. 8. 9. 10.
Total Stoppages per Quarter Hour											Average Stoppages per Loom per Hour =		

General Remarks

Erector's Signature

PARTICULARS OF CLOTHS.

Details of			Class of Yarn.
Reeds.	Picks.	Counts.	
No. of Shafts			

General, etc.

Loom Efficiencies

Loom.		Indicator Reading.		Picks Registered.	Loom Efficiency.
Number.	Speed.	Start.	Finish.		
Average Speed..............		Average Picks Registered................		=	.... %
Calculation for Loom Efficiency.					
Speed................ × 60 × 2 =				which represents 100% efficiency.	

Time Spent on Loom Stoppages

Length of 10 consecutive Stops in Minutes and Seconds.										Average.
(A fair Average is One Minute for each Stoppage.)										

Average Stoppage per Loom per Hour	Number of Looms per Weaver	Average Length of each Stoppage	Total Time
×	×	=	Minutes.

Time Spent in Filling Batteries

Average Number of Bobbins or Cops in Battery	=
Life of Bobbins or Cops .... Mins. Therefore Bobbins per Hour	=
Time Taken to Fill Batteries {If Bobbins, allow 2 Mins. If Cops, allow 4 Mins.} ..	=
Number of Looms to a Weaver	=

Looms per Weaver	Cops or Bobbins used per Hour	If Bobbins 12 If Cops 6	Total Time
×	÷	=	Minutes.

Total Time Spent per Hour Attending to Looms

Time Spent on Loom Stoppages		Mins.
Time Spent Filling Batteries		Mins.
General Supervision and Removing Cloth, &c.	Allow	10 Mins.
Total Time Occupied per Hour		Mins.

(A Weaver should not be occupied more than 40 minutes in each hour.)

General Remarks

APPENDIX III

WAGE LISTS FOR NORTHROP LOOMS

No. 1 *Shed*—Grey goods—Lancashire. 23rd June 1926.

32-inch twills, woven on 36-inch loom	6·33	pence per 100,000 picks.
36 ,, ,,	6·55	,, ,, ,,
40 ,, ,,	6·78	,, ,, ,,

Tacklers, £4, 4s. 6d. for 94 looms, with bonus of 1s. 4d. for each 1 per cent. over 80 per cent. efficiency.

No. 2 *Shed*—Coloured goods—Lancashire. 5th May 1926.

For cloth up to and including 37 inches wide,	0·72	pence per 10,000 picks.
,, ,, 38 to 42 inches wide (inclusive),	0·77	,, ,, ,,
All cloth woven in 68-inch looms	1·62	,, ,, ,,

Above prices to be subject to the current advance on the uniform list, which at present is 95 per cent.

Weavers not to have more than 4 dobbies per 10 looms, or *pro rata* for any additional number of looms.

One battery filler per 60 looms.

All weft to be taken to the weavers, and all cloth to be taken away from the weavers.

Looms to be cleaned by special labour, and any loom having to wait for weft for more than 8¾ consecutive working hours to be paid at the rate of 80 per cent. of the average number of picks on the other looms the same weaver is running.

Weavers competent to run more than 10 looms to be allowed to do so.

No. 3 *Shed*—Scotland. 5th August 1926.

Weavers, 2 pence per 20,000 picks, plus 2½ per cent. (average £2, 3s. per week).

Assistants, battery fillers, cleaners, etc., commence at 13s. and increase 1s. half-yearly. Maximum, 21s. per week.

	£	s.	d.	
Overlookers—Standing wage	£3	5	8	per week.
1 to 70 per cent., at 3d.	0	17	6	
71 per cent. and over, at 6d. (average)	0	15	1	
	£4	18	3	average wage.

No. 4 *Shed*—Scotland.

Weavers—Plain	$2\frac{3}{8}$ pence per 20,000 picks.
Dobby	$2\frac{1}{2}$,, ,, ,,
Jacquard	$2\frac{7}{8}$,, ,, ,,
Smash piecers	£2 12s. per week.
Battery fillers	8s. to 12s. per week.
Cleaners and oilers	£1, 5s. ,,
Overlookers, standing wage	£3, 12s. 6d. ,, (plus a premium of 3d. per 1 per cent. from 1 to 60 per cent.; and of 6d. per 1 per cent. over 60).

All wages subject to an addition of $7\frac{1}{2}$ per cent.

No. 5 *Shed*—Yorkshire. 80- and 85-inch Northrop looms.

Tappet looms—Woollen warp and woollen weft, 1 penny per 2600 picks.
Worsted warp and woollen weft, 1 ,, ,, 2900 ,,
Worsted warp and worsted weft, 1 ,, ,, 3200 ,,

Dobby looms—

	1 Beam, 8 Shafts, and under.	1 Beam, 9 Shafts, and over.	2 Beams, 9 Shafts, and over.
Woollen warp and woollen weft	1d. per 2300	1d. per 2200	1d. per 2000
Worsted warp and woollen weft	,, 2600	,, 2500	,, 2300
Worsted warp and worsted weft	,, 3000	,, 2900	,, 2700

Add to the above figures—

15·625 per cent. to bring into line with 48-hour week scale.
10 per cent. increase, August 1919.
A percentage equal to current Board of Trade cost of living index figure.

NOTE.—Weavers' further $2\frac{1}{2}$ per cent. on above.

APPENDIX IV

LIST OF MAKERS OF AUTOMATIC LOOMS AND ATTACHMENTS

Firm.	Place.	Systems.
British Northrop Loom Co., Ltd.	Blackburn	Northrop cop changer.
Crompton & Knowles	Worcester, Mass.	Own cop and shuttle changers.
Draper Corporation	Hopedale, Mass.	Northrop cop changer.
G. Hattersley & Sons, Ltd.	Keighley	Hattersley shuttle changer.
Pilling & Sons, Ltd.	Colne	Terry attachment.
Stafford Loom Co.	Readville, Mass.	Stafford shuttle changer.
Urquhart Lindsay & Robertson Orchar, Ltd.	Dundee	Walter shuttle changer.
Vickers (Crayford), Ltd.	Crayford	Vickers - Stafford shuttle changer.
Whittaker Automatic Looms, Ltd.	Blackburn	Own attachment.
Gawsworth Patents	Manchester	Gawsworth attachment.
Apparechio Zattera	Busto Arsizio	Own apparatus.
Apparechio Zell	Legnano	Own and attachment.
Ateliers de Construction Ruti	Ruti (Zurich)	Northrop. Steinen-Ruti. Own cop changer.
Ateliers de Sedan	Sedan	Northrop.
Ateliers des Vosges	Remiremont	Own.
Baer	Zurich	Own and attachment.
Boudet	La Varenne St Hilaire	Own attachment.
Deiderich	Bourgoin (Isère)	Own cop changer (Northrop principle).
Fontana	Legnano	Own and attachment.
Gabler	Munich	Own attachment.
Hartmann	Chemnitz	Own cop changer (Northrop principle).
Olivier	Roubaix	Own attachment, Steinen.

Firm.	Place.	Systems.
Roscher	Neugersdorf (Saxony)	Northrop.
Sächsiche Webstuhlfabrik (Louis Schönherr).	Chemnitz . .	Own cop changer (Northrop principle).
Société Alsacienne de Constructions Mécaniques.	Mulhouse . .	Own cop changer (Northrop principle).
Société Dauphinoise . .	Bourgoin (Isère) .	Northrop.
Wagemans	Brussels . . .	Own attachment.
Zandhov	Prague . . .	Northrop.

The majority of the attachments work on the Northrop principle. In the Steinen-Ruti system, air currents are used for the threading up of the shuttles.

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